

PATCH PANEL

COLOR LEGEND

○ UNASSIGNED

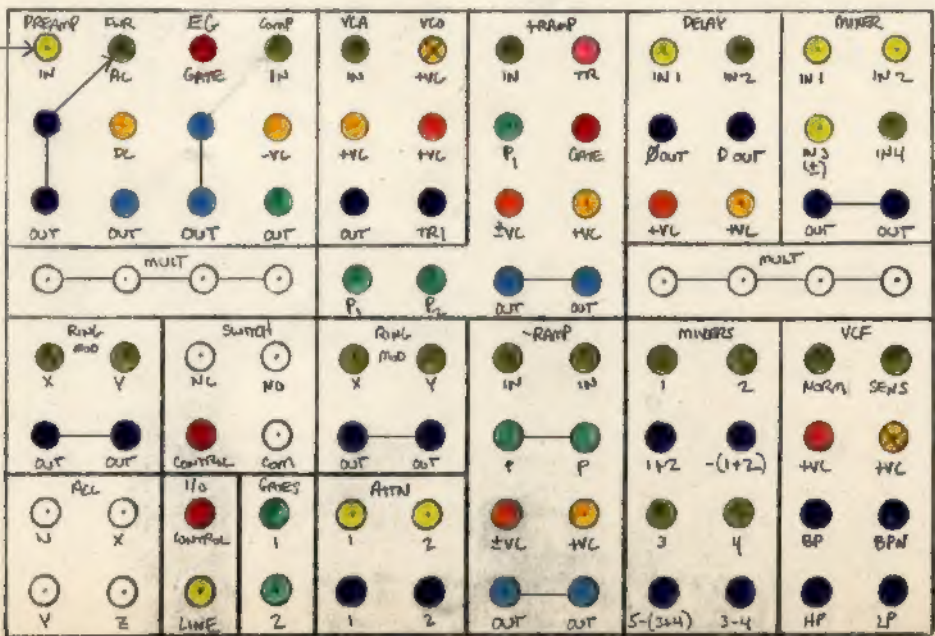
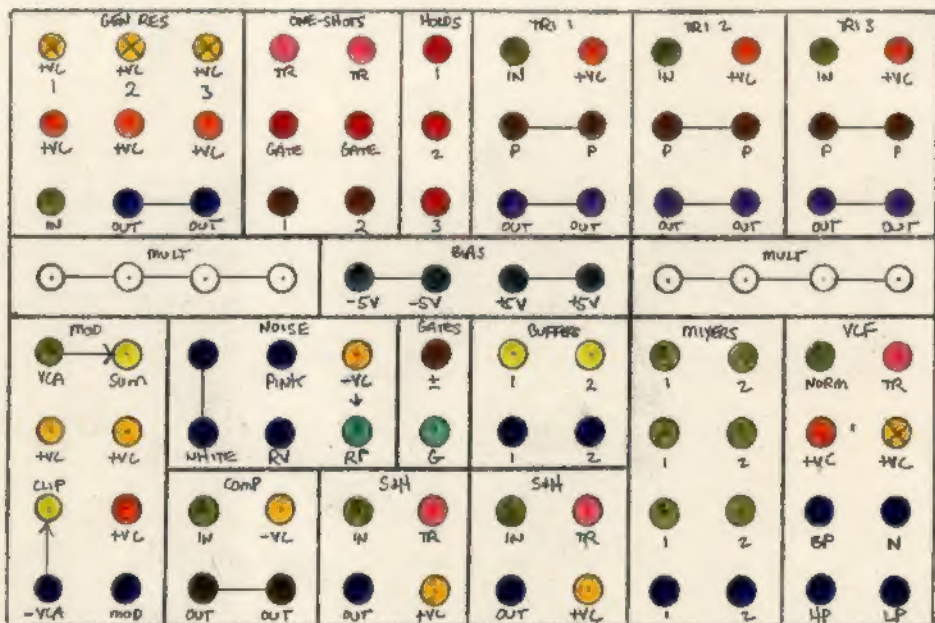
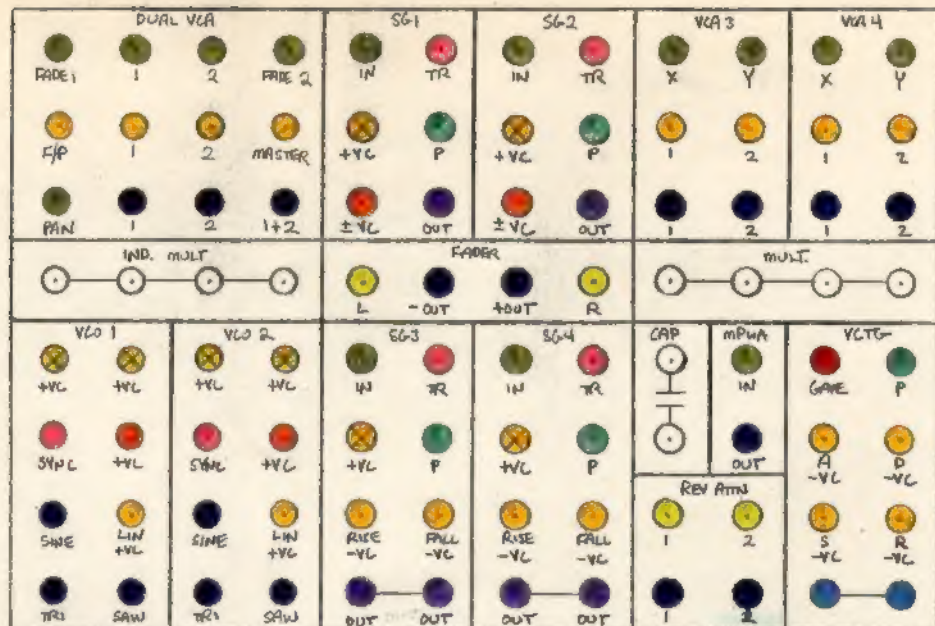
INPUTS

- MAIN
- MAIN WITH ATTENUATOR
- CONTROL
- CONTROL, 1VOLT/OCTAVE
- CONTROL WITH ATTENUATOR
- GATE
- TRIGGER

OUTPUTS

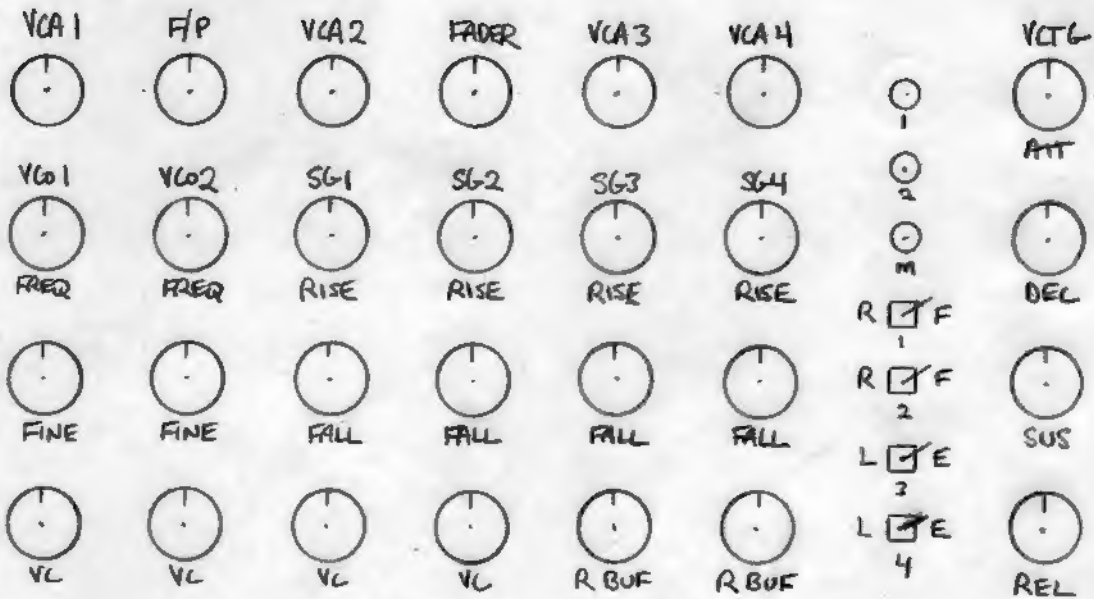
- BIPOLAR ANALOG
- BIPOLAR ANALOG, UNIPOLAR CYCLE
- UNIPOLAR ANALOG
- BIPOLAR BINARY
- UNIPOLAR BINARY
- FIXED BIAS

RICH BREWSTER, 5/80

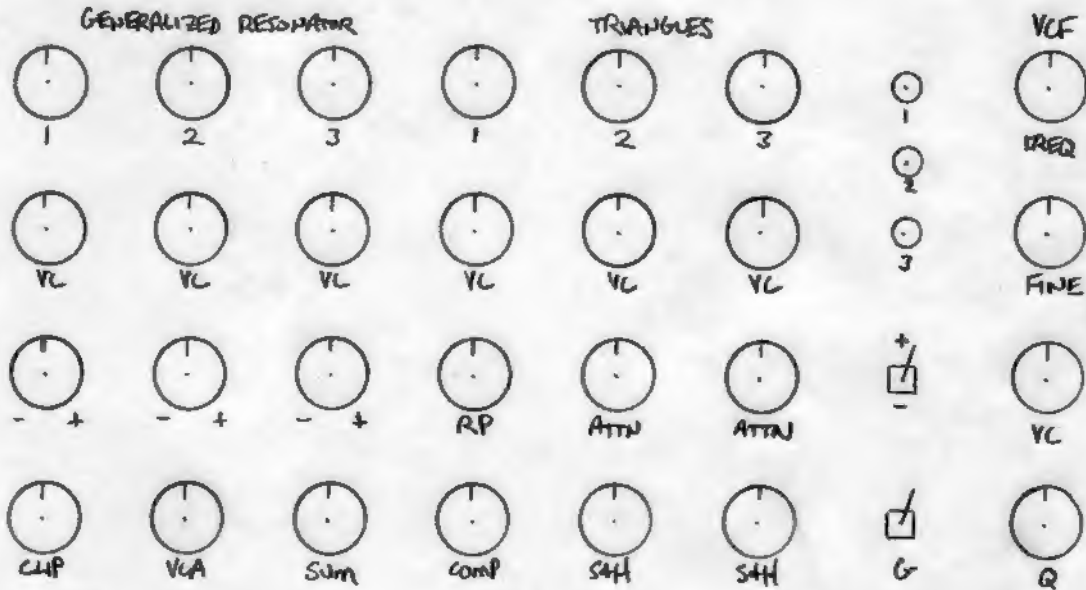


CONTROL PANELS

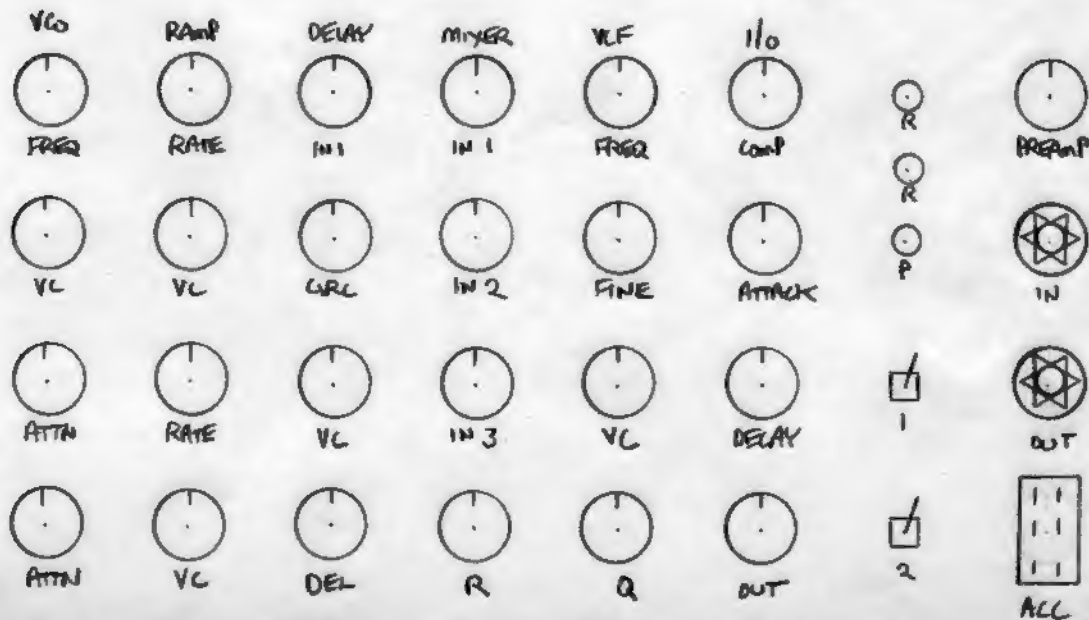
Box 3



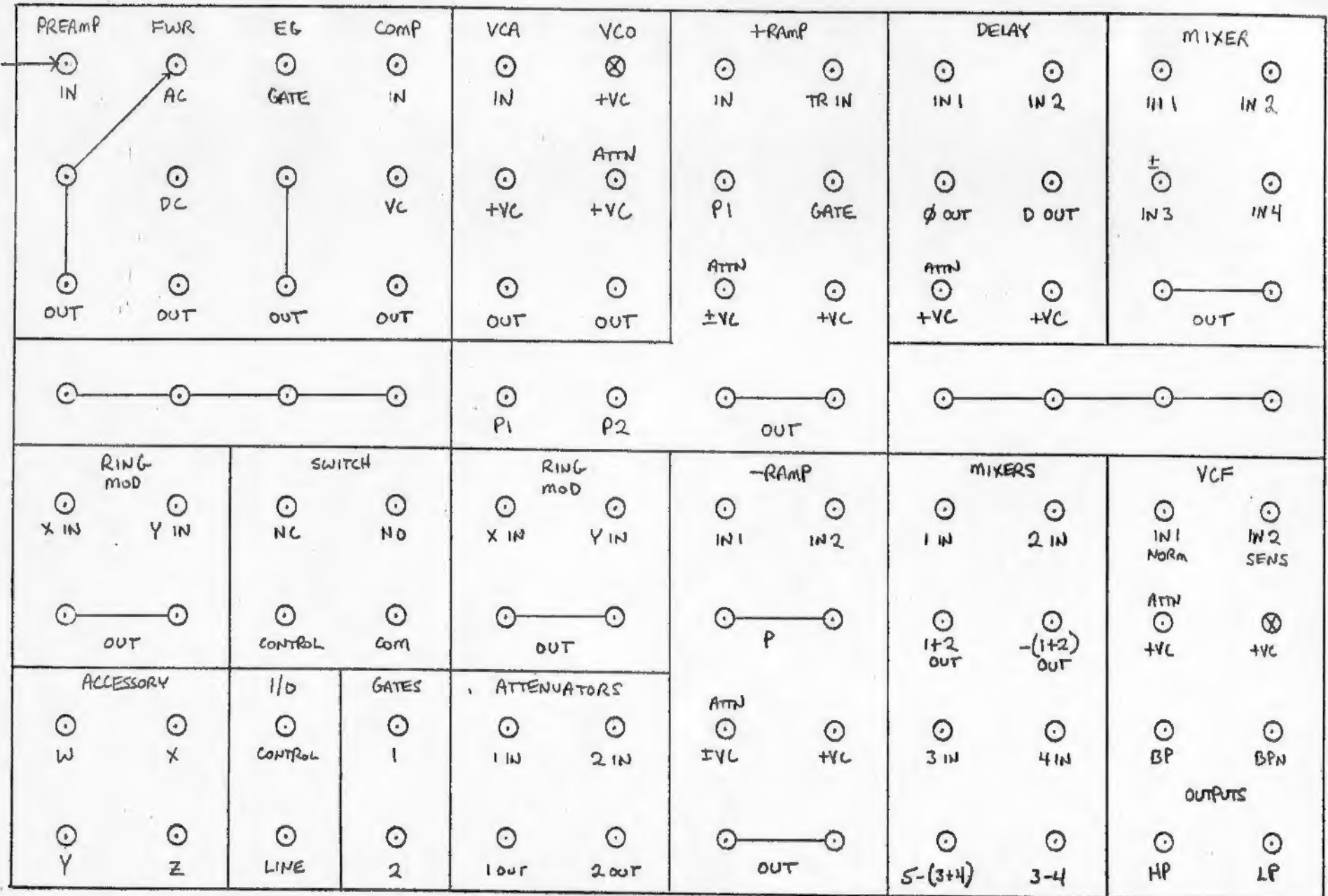
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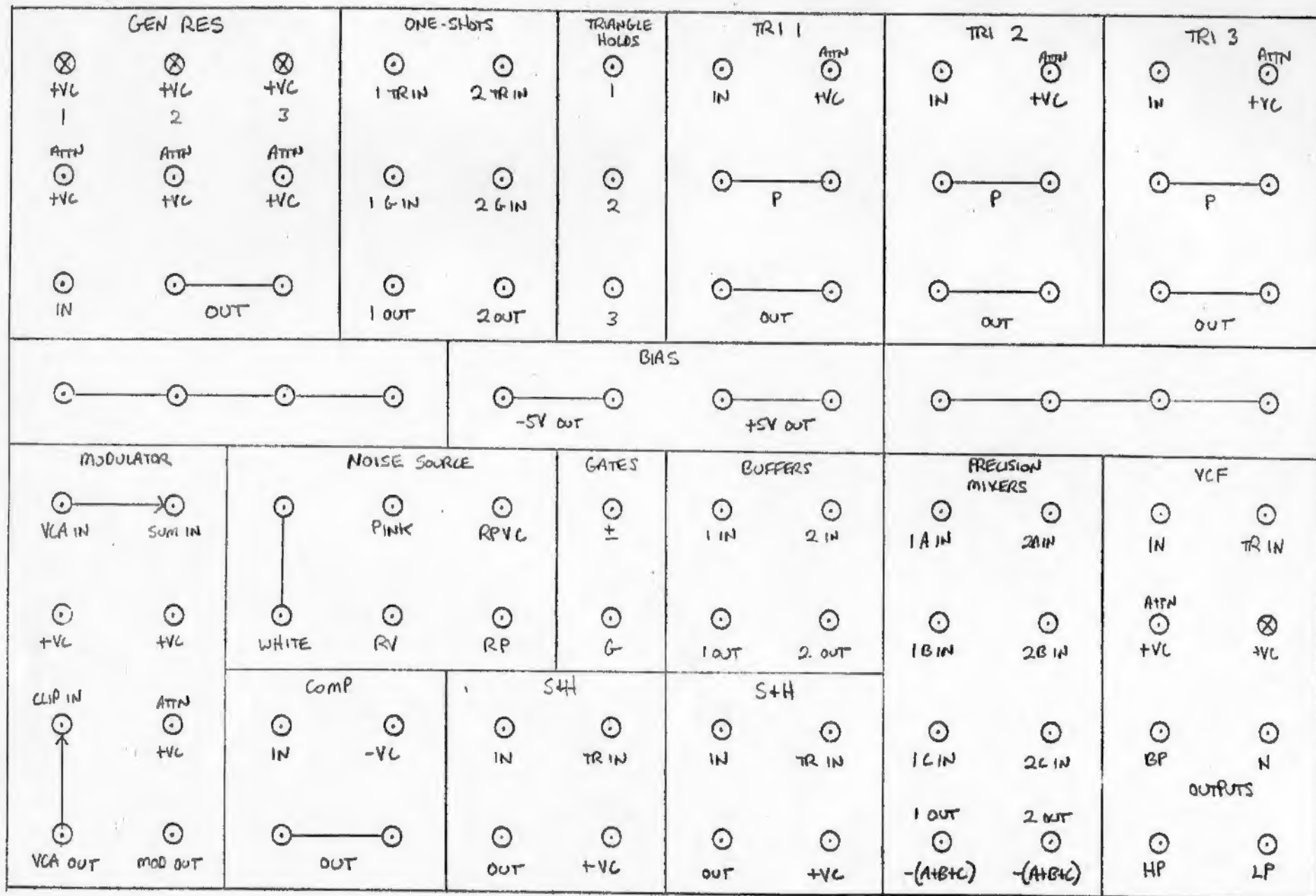
Box 1



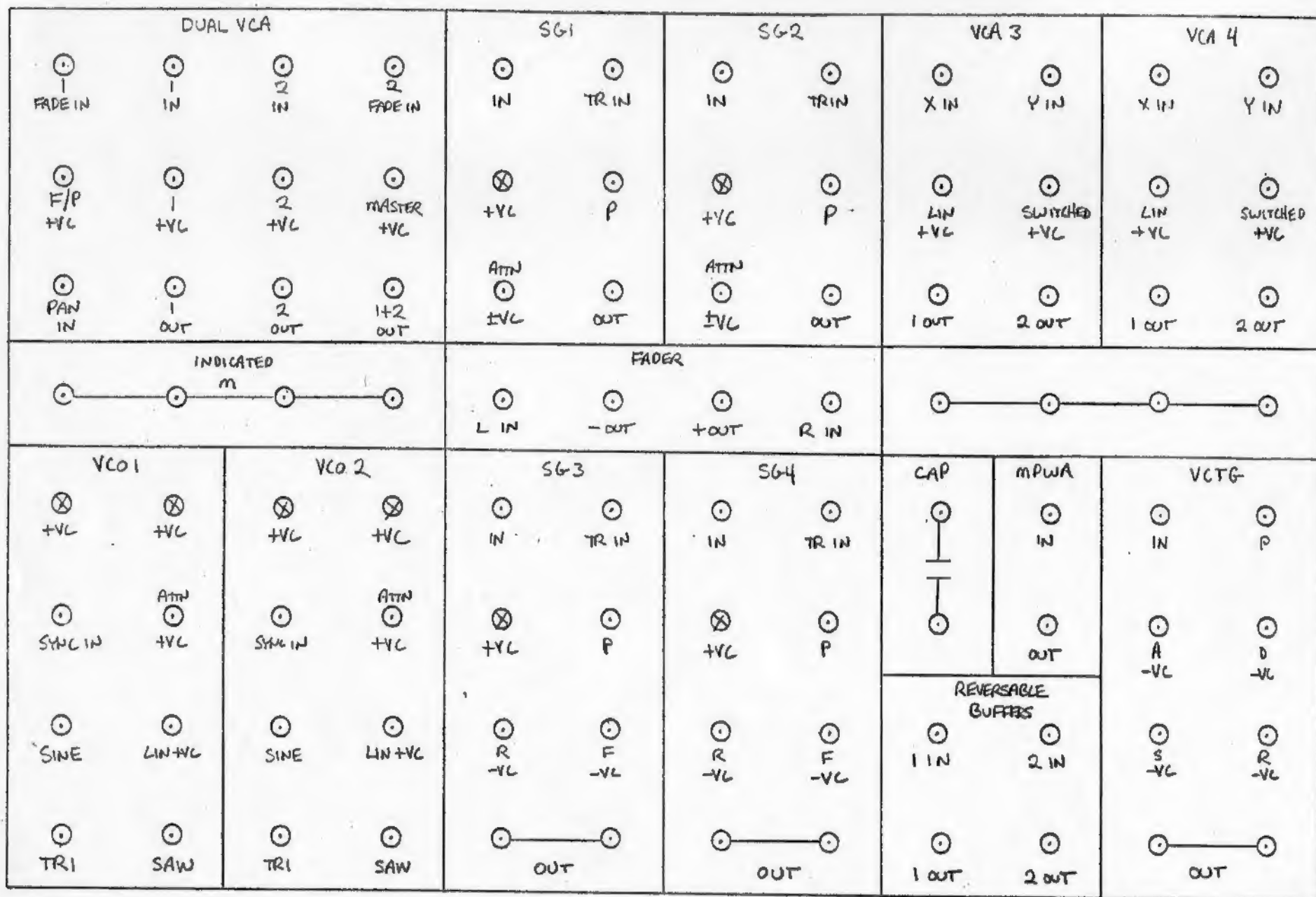
UNIT ONE PATCH PANEL



UNIT TWO PATCH PANEL

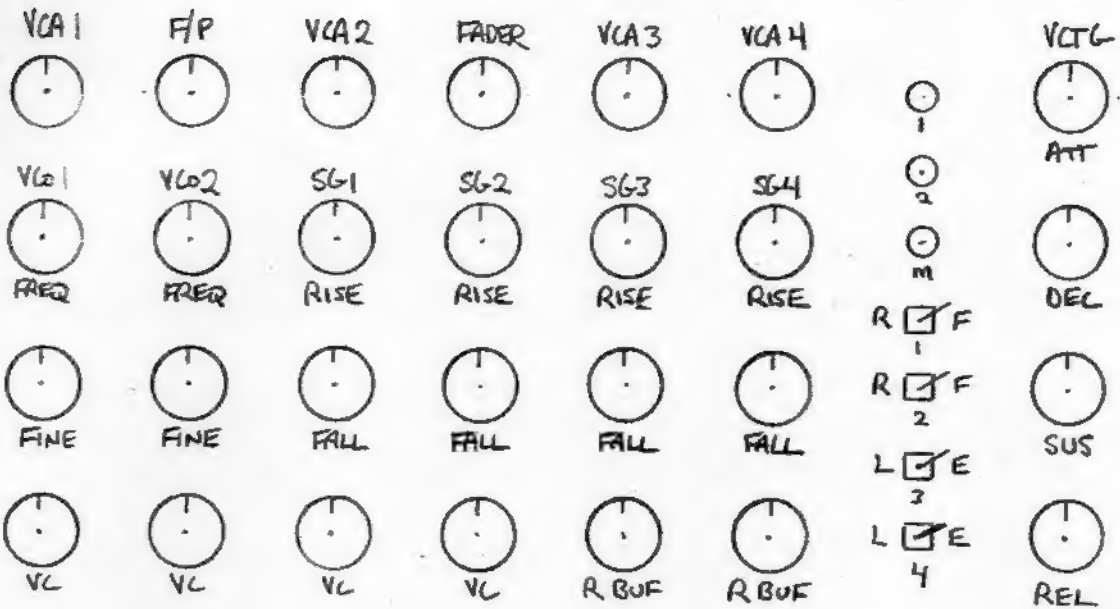


UNIT THREE PATCH PANEL

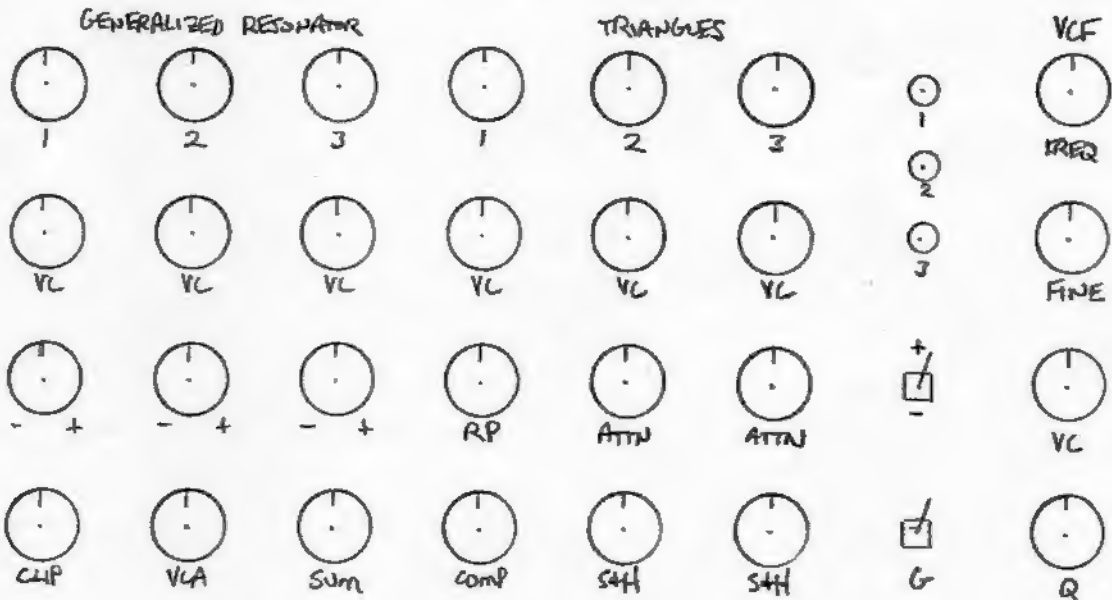


CONTROL PANELS

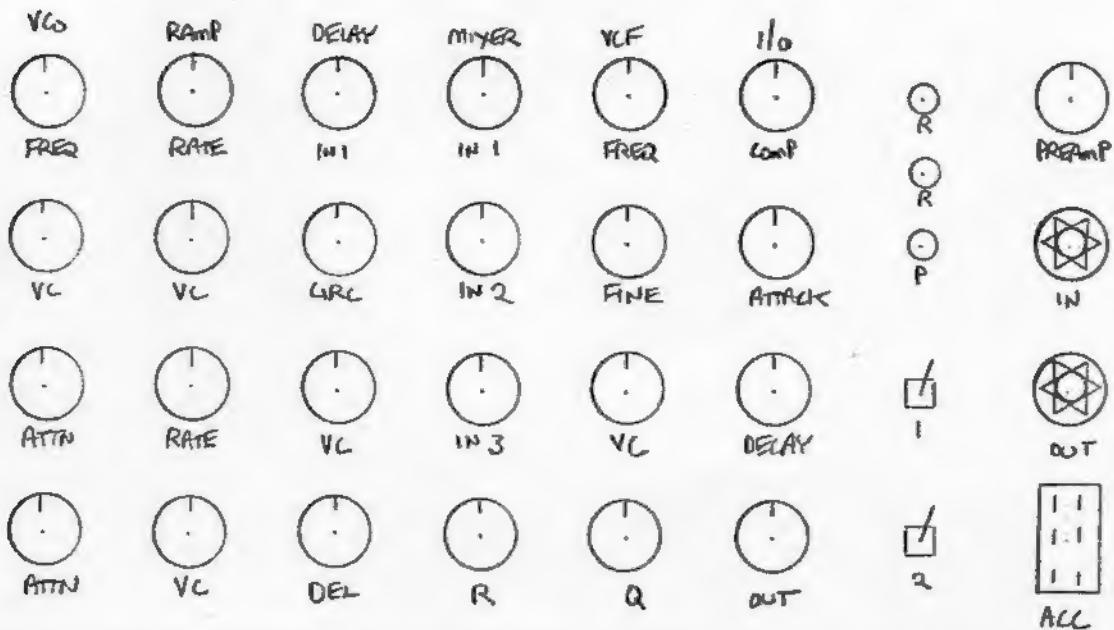
Box 3



Box 2



Box 1



Box 1
MODULE LIST

VCO - WIDE RANGE TRIANGLE, IN/OUT TEMPO STABILITY
VCA - AC COUPLED, NO PANEL CONTROLS
VCF - 4TH ORDER STATE VARIABLE, IN/OUT TEMPO STABILITY
ENVELOPE GENERATOR - SIMPLE AR, GATE DRIVEN
FULL WAVE RECTIFIER - ABSOLUTE VALUE CIRCUIT
I/O SWITCH WITH PREAMP AND LINE DRIVER
COMPARATOR
POSITIVE RAMP GENERATOR
NEGATIVE RAMP GENERATOR
ANALOG DELAY
MIXER WITH ATTENUATED INPUTS
UNATTENUATED INPUT MIXERS / INVERTERS
DUAL RING MODULATORS
BILATERAL ELECTRONIC SWITCH
DUAL MANUAL GATE SWITCHES
DUAL UNBUFFERED LINEAR ATTENUATORS
DUAL FOUR-POINT MULTIPLES
ACCESSORY CONNECTOR (KEYBOARD PATCH)

Box 2
MODULE LIST

THREE TRIANGLE MODULES

DUAL ONE-SHOTS (CONVERT TRIANGLE TO S+H)

DUAL SLEW-LIMITED SAMPLE AND HOLD
COMPARATOR

NOISE SOURCE

DUAL PRECISION INVERTING MIXERS

VCF - 2ND ORDER STATE VARIABLE, 1V/OCT TEMPO STABILITY

TIMBRE MODULATOR / VCA

GENERALIZED RESONATOR

± GATE SWITCH

MANUAL GATE OR PULSE SWITCH

DUAL BUFFERED AUDIO TAPER ATTENUATORS, GAIN = +2

±5V BIAS SOURCES

DUAL FOUR-POINT MULTIPLES

Box 3
MODULE LIST

FOUR SLEW GENERATORS

DUAL WIDE RANGE VCO'S, 1V/OCT TEMPO STABLE

DUAL VCA

DUAL VCA

MANUAL FADER

VOLTAGE CONTROLLED ENVELOPE GENERATOR

DUAL REVERSIBLE BUFFERS, GAIN = ±1.75

MULTI-PHASE WAVEFORM ANIMATOR

PATCHABLE CAPACITOR

DUAL 4-POINT MULTIPLES, ONE WITH INDICATOR

BRIEF MODULE DESCRIPTION

VOLTAGE CONTROLLED OSCILLATORS (SEE MULTIFUNCTION)

Box #

VCO 1, VCO 2

3

WIDE RANGE - SLOW LFO TO 20 KHZ.

2 IN/OCT FM INPUTS, 1 ATTENUATED LOG FM INPUT.

LINEAR FM INPUT, SYNC INPUT.

SINE, TRIANGLE, SAWTOOTH WAVEFORMS.

VCO 3

1

WIDE RANGE - SLOW LFO TO 20 KHZ.

1 IN/OCT FM INPUT, 1 ATTENUATED LOG FM INPUT.

TRIANGLE WAVEFORM.

VOLTAGE CONTROLLED AMPLIFIERS

3

VCA'S 1 AND 2 (DUAL VCA)

3

USES: TWO INDEPENDENT LINEAR VCA'S.

VOLTAGE CONTROLLED FADE OR PAN WITH

SEPERATE VC OF FADE/PAN AND FINAL LEVELS.

VOLTAGE CONTROLLED MIXING.

VCA 3, VCA 4

3

EACH IS A UNIVERSAL AMPLITUDE PROCESSOR

USES: NORMAL VCA, REVERSE VCA.

FADE, REVERSE FADE.

PAN, REVERSE PAN.

SIMULTANEOUS FADE, PAN.

LINEAR OR EXPONENTIAL RESPONSE.

VCA 5

1

SIMPLE LINEAR VCA, AC COUPLED INPUT.

VCA 6 (PART OF TIMBRE MODULATOR)

2

SIMPLE LINEAR VCA.

3 CONTROL INPUTS, SIGNAL IS INVERTED.

KEYBOARD

N.A.

3 OCTAVE DIGITAL KEYBOARD WITH:

MODULATION WHEEL FOR BEND OR MODULATION.

BUILT IN SINE WAVE VIBRATO OSCILLATOR.

KEYBOARD SPLIT FOR 5 OCTAVE COVERAGE.

TUNING OVER 1 OCTAVE RANGE.

IN/OCT OR ANY MICRO OR MACRO SCALING, + OR -.

PORTAMENTO, EXPONENTIAL.

AUTOMATIC ARPEGGIATION, RANDOM NOTE SELECTION.

VOLTAGE CONTROLLED FILTERS

Box #

VCF 1, FOURTH-ORDER STATE VARIABLE.

1

TWO SIGNAL INPUTS, NORMAL AND SENSITIVE.

TWO CONTROL INPUTS, $1V/OCT$ AND ATTENUATED LOG .

LOW, HIGH, \pm BAND PASS, PLUS BAND PASS NOTCH OUTPUTS.

VCF 2, SECOND-ORDER STATE VARIABLE.

2

TWO SIGNAL INPUTS, NORMAL AND TRIGGER.

TWO CONTROL INPUTS, $1V/OCT$ AND ATTENUATED LOG .

LOW, HIGH, \pm BAND PASS, PLUS NOTCH OUTPUTS.

BOTH VCF 1 AND 2 CAN BE MADE TO FUNCTION AS

SINE WAVE OSCILLATORS WITH SUBAUDIO TO 20 KHZ RANGE.

ENVELOPE GENERATORS (SEE MULTIFUNCTION)

3

VCTG 1

WIDE RANGE ADSR TYPE GENERATOR.

ALL PARAMETERS VOLTAGE CONTROLLABLE.

CAN BE PATCHED TO SELF-CYCLE.

EG 1 - SIMPLE GATE DRIVEN ASR.

1

RING MODULATORS

MULTIPLIER 1, MULTIPLIER 2.

X & Y INPUTS, OUTPUT.

MULTIPLIER 1 HAS AC COUPLED INPUTS.

1

NOISE SOURCE

2

WHITE, PINK, LOW FREQUENCY, RANDOM PULSE OUTPUTS.

RANDOM PULSE RATE IS VOLTAGE CONTROLLABLE.

ANALOG DELAY

1

VOLTAGE CONTROLLED DELAY.

TWO SIGNAL INPUTS, 1 ATTENUATED.

TWO CONTROL INPUTS, 1 ATTENUATED.

PHASOR OUTPUT, DELAYED OUTPUT.

RECIRCULATION / FLANGER CONTROL.

SAMPLE AND HOLD (1 & 2)

2

SLEW LIMITED S&H WITH VC OF SLEW RATE.

SIGNAL IN, SAMPLE TRIGGER IN, OUTPUT.

MULTIFUNCTION MODULES

Box #

SLEW GENERATORS 1, 2, 3, 4.

3

USES: WIDE RANGE VCO, SLOW LFO TO 5 KHZ.

AD, AR, ASR GENERATOR.

TWO TOGETHER CAN MAKE VC ADSR.

LINEAR VC LAG-PROCESSOR.

SEPERATE VC OF ATTACK AND DELAY.

ENVELOPE FOLLOWER.

VC FREQUENCY DIVIDER.

POSITIVE AND NEGATIVE RAMP GENERATORS.

1

USES: WIDE RANGE VCO, SLOW LFO TO 2 KHZ.

COMBINED TO FORM AD, AR, ASR GENERATOR.

LINEAR VC LAG PROCESSOR.

ENVELOPE FOLLOWER (NEG).

VC FREQUENCY DIVIDER.

TRIANGLES 1, 2, 3.

2

USES: WIDE RANGE VCO, SLOW LFO TO 1 KHZ.

LINEAR VC LAG PROCESSOR.

ASR ENVELOPE GENERATOR.

SLEW LIMITED SAMPLE AND HOLD (WITH ONE SHOT).

TRACK AND HOLD.

MULTIPLE CONNECTIONS

TWO 4-POINT COMMON PATCHPOINTS ARE

1, 2, 3

AVAILABLE ONEACH BOX.

BOX 3 HAS A MULTIPLE MONITERED BY LED.

CAPACITOR

3

A PATCHABLE 2.2 μ F NON POLAR CAPACITOR IS
PROVIDED FOR AC COUPLING PATCHES.

BIAS

2

FIXED +AND - FIVE VOLT BIAS OUTPUTS ARE
MADE AVAILABLE ON THE PATCHBAY.

MIXERS

Box #

MIXER 1:

TWO NON-INVERTING ATTENUATED INPUTS, MAX GAIN OF +2.33.

CENTER OFF INVERTING OR NON INVERTING UNITY GAIN ATTENUATED INPUT.

UNITY GAIN NON-ATTENUATED INPUT.

MIXER 2:

TWO NON-ATTENUATED INPUTS.

SUM AND INVERTED SUM OUTPUTS.

MIXER 3:

TWO NON-ATTENUATED INPUTS.

SUM AND DIFFERENCE OUTPUTS.

MIXERS 4, 5:

PRECISION 3 INPUT NON-ATTENUATED INVERTING MIXERS.

MANUAL ATTENUATORS

ATTENUATOR 1 + 2:

TWO PATCHABLE POTENTIOMETERS, 100K LINEAR.

BUFFERS 1 + 2:

TWO BUFFER AUDIO TAPER ATTENUATORS, MAX GAIN = +2.

REVERSIBLE BUFFERS:

TWO CENTER OFF INVERTING OR NON-INVERTING

VARIABLE GAIN BUFFERS, MAX GAIN = ± 1.75 .

MANUAL FADER:

LEFT AND RIGHT INPUTS.

INVERTING AND NON INVERTING UNITY GAIN OUTPUTS.

FULLY BUFFERED.

MANUAL GATE SWITCHES

1 AND 2:

DEBOUNDED GATE, ON OR MOMENTARY ACTION.

GATE:

GIVES EITHER DEBOUNDED GATE OR

1ms PULSE.

 \pm GATE:NOT DEBOUNDED ACCESS TO $\pm 5V$ BIAS.

SPECIAL MODULES

Box #

MULTIPHASED WAVEFORM ANIMATOR:

3

ONE INPUT, ONE OUTPUT DEVICE FOR
IMPARTING 8 SIMULTANEOUS PHASE SHIFTS TO A
SAWTOOTH WAVE, OR ENHANCEMENT OF OTHER SIGNALS.

TIMBRE MODULATOR:

2

CLIPPING CIRCUIT AND VCA FOR
VC OF HARMONIC CONTENT.
CLIPPER AND VCA USEABLE SEPERATELY.

GENERALIZED RESONATOR:

2

THREE CASCADED VOLTAGE CONTROLLED MONOSTABLES,
SIGNAL INPUT AND OUTPUT.
SIX VC INPUTS, 3 ATTENUATED.
MANUAL OUTPUT MIXER.
THIS IS AN EXPERIMENTAL "PULSE MODULATOR".

INPUT/OUTPUT CONTROL

1

PROVIDES BUFFERING AND LEVEL MATCHING
WITH IN/OUT VC SWITCHING. PROVIDED FOR
USE WHEN PROCESSING GUITAR, MIC, ETC.

ONE SHOTS

2

USE WITH TRIANGLE TO MAKE SAMPLE AND HOLD.
SAMPLE, TRACK INPUTS, OUTPUT.
USE TO GENERATE PULSE WAVEFORMS.

MISCELLANEOUS MODULES

Box #

COMPARATORS

COMP 1:

1

COMPARES INPUT WITH REFERENCE VOLTAGE, OUTPUT
IS HIGH IF INPUT IS HIGHER THAN REFERENCE.

REFERENCE IS MANUALLY ADJUSTABLE AND VOLTAGE CONTROLLABLE.

USE FOR PULSE GENERATION AND MODULATION,

SQUARE WAVE GENERATION,

GATE SIGNAL GENERATION.

COMP 2:

2

SAME AS COMP 1 EXCEPT FOR BIPOLAR OUTPUT.

FULL WAVE RECTIFIER

FWR 1:

1

ABSOLUTE VALUE CIRCUIT, INVERTS INPUT IF NEGATIVE.

BOTH AC AND DC COUPLED INPUTS.

USE AS TIMBRE MODIFIER, "FUZZTONE",

V/L WAVESHAPER.

CONTROLLED SWITCH

1

SINGLE POLE DOUBLE THROW SWITCH, ELECTRONICALLY

CONTROLLED BY GATE INPUT.

COMMON TERMINAL MAY BE USED AS EITHER INPUT OR OUTPUT.

BRIEF MODULE DESCRIPTION

VOLTAGE CONTROLLED OSCILLATORS (SEE MULTIFUNCTION)

Box #

VCO 1, VCO 2

3

WIDE RANGE - SLOW LFO TO 20 KHZ.

2 V/OCT FM INPUTS, 1 ATTENUATED LOG FM INPUT.

LINEAR FM INPUT, SYNC INPUT.

SINE, TRIANGLE, SAWTOOTH WAVEFORMS.

VCO 3

1

WIDE RANGE - SLOW LFO TO 20 KHZ.

1 V/OCT FM INPUT, 1 ATTENUATED LOG FM INPUT.

TRIANGLE WAVEFORM.

VOLTAGE CONTROLLED AMPLIFIERSVCA's 1 AND 2 (DUAL VCA)

3

USES: TWO INDEPENDENT LINEAR VCA'S.

VOLTAGE CONTROLLED FADE OR PAN WITH

SEPERATE VC OF FADE/PAN AND FINAL LEVELS.

VOLTAGE CONTROLLED MIXING.

VCA 3, VCA 4

3

EACH IS A UNIVERSAL AMPLITUDE PROCESSOR

USES: NORMAL VCA, REVERSE VCA.

FADE, REVERSE FADE.

PAN, REVERSE PAN.

SIMULTANEOUS FADE, PAN.

LINEAR OR EXPONENTIAL RESPONSE.

VCA 5

1

SIMPLE LINEAR VCA, AC COUPLED INPUT.

VCA 6 (PART OF TIMBRE MODULATOR)

2

SIMPLE LINEAR VCA.

3 CONTROL INPUTS, SIGNAL IS INVERTED.

KEYBOARD

N.A.

3 OCTAVE DIGITAL KEYBOARD WITH:

MODULATION WHEEL FOR BEND OR MODULATION.

BUILT IN SINE WAVE VIBRATO OSCILLATOR.

KEYBOARD SPLIT FOR 5 OCTAVE COVERAGE.

TUNING OVER 1 OCTAVE RANGE.

 V/OCT OR ANY MICRO OR MACRO SCALING, + OR -.

PORTAMENTO, EXPONENTIAL.

AUTOMATIC ARPEGGIATION, RANDOM NOTE SELECTION.

VOLTAGE CONTROLLED FILTERS

Box #

VCF 1, FOURTH-ORDER STATE VARIABLE.

1

TWO SIGNAL INPUTS, NORMAL AND SENSITIVE.

TWO CONTROL INPUTS, 1V/OCT AND ATTENUATED LOG.

LOW, HIGH, + BAND PASS, PLUS BAND PASS NOTCH OUTPUTS.

VCF 2, SECOND-ORDER STATE VARIABLE.

2

TWO SIGNAL INPUTS, NORMAL AND TRIGGER.

TWO CONTROL INPUTS, 1V/OCT AND ATTENUATED LOG.

LOW, HIGH, + BAND PASS, PLUS NOTCH OUTPUTS.

BOTH VCF 1 AND 2 CAN BE MADE TO FUNCTION AS
SINE WAVE OSCILLATORS WITH SUBAUDIO TO 20 KHZ RANGE.ENVELOPE GENERATORS (SEE MULTIFUNCTION)

3

VCTG 1

WIDE RANGE ADSR TYPE GENERATOR.

ALL PARAMETERS VOLTAGE CONTROLLABLE.

CAN BE PATCHED TO SELF-CYCLE.

EG 1 - SIMPLE GATE DRIVEN ASR.

1

RING MODULATORS

MULTIPLIER 1, MULTIPLIER 2.

X + Y INPUTS, OUTPUT.

MULTIPLIER 1 HAS AC COUPLED INPUTS.

1

NOISE SOURCE

2

WHITE, PINK, LOW FREQUENCY, RANDOM PULSE OUTPUTS.

RANDOM PULSE RATE IS VOLTAGE CONTROLLABLE.

ANALOG DELAY

1

VOLTAGE CONTROLLED DELAY.

TWO SIGNAL INPUTS, 1 ATTENUATED.

TWO CONTROL INPUTS, 1 ATTENUATED.

PHASOR OUTPUT, DELAYED OUTPUT.

RECIRCULATION / FLANGER CONTROL.

SAMPLE AND HOLD (1 & 2)

2

SLEW LIMITED S+H WITH VC OF SLEW RATE.

SIGNAL IN, SAMPLE TRIGGER IN, OUTPUT.

MISCELLANEOUS MODULES

Box #

COMPARATORS

COMP 1:

1

COMPARES INPUT WITH REFERENCE VOLTAGE, OUTPUT
IS HIGH IF INPUT IS HIGHER THAN REFERENCE.
REFERENCE IS MANUALLY AND VOLTAGE CONTROLLABLE.
USE FOR PULSE GENERATION AND MODULATION,
SQUARE WAVE GENERATION,
GATE SIGNAL GENERATION.

COMP 2:

2

SAME AS COMP 1 EXCEPT FOR BIPOLAR OUTPUT.

FULL WAVE RECTIFIER

FNR 1:

1

ABSOLUTE VALUE CIRCUIT, INVERTS INPUT IF NEGATIVE.
BOTH AC AND DC COUPLED INPUTS.
USE AS TIMBRE MODIFIER, "FUZZTONE",
VC WAVE SHAPER.

CONTROLLED SWITCH

1

SINGLE POLE DOUBLE THROW SWITCH, ELECTRONICALLY
CONTROLLED BY GATE INPUT.
COMMON TERMINAL MAY BE USED AS EITHER INPUT OR OUTPUT.

MULTIFUNCTION MODULES

Box #

SLEW GENERATORS 1, 2, 3, 4.

3

USES: WIDE RANGE VCO, SLOW LFO TO 5 KHZ.

AD, AR, ASR GENERATOR.

TWO TOGETHER CAN MAKE VC ADSR.

LINEAR VC LAG-PROCESSOR.

SEPERATE VC OF ATTACK AND DECAY.

ENVELOPE FOLLOWER.

VC FREQUENCY DIVIDER.

POSITIVE AND NEGATIVE RAMP GENERATORS.

1

USES: WIDE RANGE VCO, SLOW LFO TO 2 KHZ.

COMBINED TO FORM AD, AR, ASR GENERATOR.

LINEAR VC LAG-PROCESSOR.

ENVELOPE FOLLOWER (NEG).

VC FREQUENCY DIVIDER.

TRIANGLES 1, 2, 3.

2

USES: WIDE RANGE VCO, SLOW LFO TO 1 KHZ.

LINEAR VC LAG-PROCESSOR.

ASR ENVELOPE GENERATOR.

SLEW LIMITED SAMPLE AND HOLD (WITH ONE SHOT).

TRACK AND HOLD.

MULTIPLE CONNECTIONS

TWO 4-POINT COMMON PATCHPOINTS ARE

1, 2, 3

AVAILABLE ONEACH BOX.

BOX 3 HAS A MULTIPLE MONITERED BY LED.

CAPACITOR

3

A PATCHABLE 2.2 μ F NONPOLAR CAPACITOR IS

PROVIDED FOR AC COUPLING PATCHES.

BIAS

2

FIXED +AND - FIVE VOLT BIAS OUTPUTS ARE

MADE AVAILABLE ON THE PATCHBAY.

MIXERS

Box #

MIXER 1:

1

TWO NON-INVERTING ATTENUATED INPUTS, MAX GAIN OF +2.33.
 CENTER OFF INVERTING OR NON INVERTING UNITY GAIN ATTENUATED INPUT.
 UNITY GAIN NON-ATTENUATED INPUT.

MIXER 2:

1

TWO NON-ATTENUATED INPUTS.
 SUM AND INVERTED SUM OUTPUTS.

MIXER 3:

1

TWO NON-ATTENUATED INPUTS.
 SUM AND DIFFERENCE OUTPUTS.

MIXERS 4, 5:

2

PRECISION 3 INPUT NON-ATTENUATED INVERTING MIXERS.

MANUAL ATTENUATORS

ATTENUATOR 1+2:

1

TWO PATCHABLE POTENTIOMETERS, 100K LINEAR.

BUFFERS 1+2:

2

TWO BUFFER AUDIO TAPER ATTENUATORS, MAX GAIN = +2.

REVERSIBLE BUFFERS:

3

TWO CENTER OFF INVERTING OR NON-INVERTING
 VARIABLE GAIN BUFFERS, MAX GAIN = ± 1.75 .

MANUAL FADER:

3

LEFT AND RIGHT INPUTS.

INVERTING AND NON INVERTING UNITY GAIN OUTPUTS.

FULLY BUFFERED.

MANUAL GATE SWITCHES

1 AND 2:

1

DEBOUNCE GATE, ON OR MOMENTARY ACTION.

GATE:

2

GIVES EITHER DEBOUNCE GATE OR
 1ms PULSE.

 \pm GATE:

2

NOT DEBOUNCE ACCESS TO $\pm 5V$ BIAS.

SPECIAL MODULES

Box #

MULTIPHASED WAVEFORM ANIMATOR:

3

ONE INPUT, ONE OUTPUT DEVICE FOR
IMPARTING 8 SIMULTANEOUS PHASE SHIFTS TO A
SAWTOOTH WAVE, OR ENHANCEMENT OF OTHER SIGNALS.

TIMBRE MODULATOR:

2

CLIPPING CIRCUIT AND VCA FOR
VC OF HARMONIC CONTENT.
CLIPPER AND VCA USEABLE SEPERATELY.

GENERALIZED RESONATOR:

2

THREE CASCADED VOLTAGE CONTROLLED MONOSTABLES.
SIGNAL INPUT AND OUTPUT.
SIX VC INPUTS, 3 ATTENUATED.
MANUAL OUTPUT MIXER.
THIS IS AN EXPERIMENTAL "PULSE MODULATOR".

INPUT/OUTPUT CONTROL

1

PROVIDES BUFFERING AND LEVEL MATCHING
WITH IN/OUT VC SWITCHING. PROVIDED FOR
USE WHEN PROCESSING GUITAR, MIC, ETC.

ONE SHOTS

2

USE WITH TRIANGLE TO MAKE SAMPLE AND HOLD.
SAMPLE, TRACK INPUTS, OUTPUT.
USE TO GENERATE PULSE WAVEFORMS.

MISCELLANEOUS MODULES

Box #

COMPARATORS

COMP 1:

COMPARES INPUT WITH REFERENCE VOLTAGE, OUTPUT
IS HIGH IF INPUT IS HIGHER THAN REFERENCE.
REFERENCE IS MANUALLY AND VOLTAGE CONTROLLABLE.
USE FOR PULSE GENERATION AND MODULATION,
SQUARE WAVE GENERATION,
GATE SIGNAL GENERATION.

COMP 2:

SAME AS COMP 1 EXCEPT FOR BIPOLAR OUTPUT.

FULL WAVE RECTIFIER

FWR 1:

ABSOLUTE VALUE CIRCUIT, INVERTS INPUT IF NEGATIVE.
BOTH AC AND DC COUPLED INPUTS.
USE AS TIMBRE MODIFIER, "FUZZTONE",
V_L WAVE SHAPER.

CONTROLLED SWITCH

SINGLE POLE DOUBLE THROW SWITCH, ELECTRONICALLY
CONTROLLED BY GATE INPUT.
COMMON TERMINAL MAY BE USED AS EITHER INPUT OR OUTPUT.

Box 1
MODULE LIST

VCO - WIDE RANGE TRIANGLE, IV/OUT TEMPCO STABILITY
VCA - AC COUPLED, NO PANEL CONTROLS
VCF - 4TH ORDER STATE VARIABLE, IV/OUT TEMPCO STABILITY
ENVELOPE GENERATOR - SIMPLE AR, GATE DRIVEN
FULL WAVE RECTIFIER - ABSOLUTE VALUE CIRCUIT
I/O SWITCH WITH PREAMP AND LINE DRIVER
COMPARATOR
POSITIVE RAMP GENERATOR
NEGATIVE RAMP GENERATOR
ANALOG DELAY
MIXER WITH ATTENUATED INPUTS
UNATTENUATED INPUT MIXERS / INVERTERS
DUAL RING MODULATORS
BILATERAL ELECTRONIC SWITCH
DUAL MANUAL GATE SWITCHES
DUAL UNBUFFERED LINEAR ATTENUATORS
DUAL FOUR-POINT MULTIPLES
ACCESSORY CONNECTOR (KEYBOARD PATCH)

Box 2

MODULE LIST

THREE TRIANGLE MODULES

DUAL ONE-SHOTS (CONVERT TRIANGLE TO S+H)

DUAL SLEW-LIMITED SAMPLE AND HOLDS

COMPARATOR

NOISE SOURCE

DUAL PRECISION INVERTING MIXERS

VCF - 2ND ORDER STATE VARIABLE, 1V/OCT TEMPO STABILITY

TIMBRE MODULATOR / VCA

GENERALIZED RESONATOR

\pm GATE SWITCH

MANUAL GATE OR PULSE SWITCH

DUAL BUFFERED AUDIO TAPER ATTENUATORS, GAIN = +2

$\pm 5V$ BIAS SOURCES

DUAL FOUR-POINT MULTIPLES

Box 3

MODULE LIST

FOUR SLEW GENERATORS

DUAL WIDE RANGE VCO'S, 1V/OCT TEMPO STABLE

DUAL VCA

DUAL VCA

MANUAL FADER

VOLTAGE CONTROLLED ENVELOPE GENERATOR

DUAL REVERSIBLE BUFFERS, GAIN = ± 1.75

MULTI-PHASE WAVEFORM ANIMATOR

PATCHABLE CAPACITOR

DUAL 4-POINT MULTIPLES, ONE WITH INDICATOR

Audio SYNTHESIZER
SYSTEM MANUAL + DOCUMENTATION
7/80, Rich BREWSTER

CONTENTS:

- ① LISTING OF SYSTEM MODULES → PACKAGING OVERVIEW
- ② DISCUSSION OF SIGNAL STANDARDS
- ③ FUNCTIONAL DISCUSSION OF EACH MODULE
- ④ SCHEMATICS

THE SYSTEM DESCRIBED HERE IS PHYSICALLY CONTAINED IN 4 PACKAGES, EACH SEPARATELY POWERED AND USABLE INDIVIDUALLY OR TOGETHER. ~~AS A LARGER SYSTEM~~ THEY ARE REFERRED TO AS BOXES #1, #2, #3, AND KEYBOARD. BOXES #1-#3 ARE RACK MOUNTABLE; EASILY FASTEN TOGETHER AND COME APART TO SUIT USAGE NEEDS.

MODULES ARE ELECTRICALLY DISCRETE, BUT PANELS AND PATCH BAYS ARE INTEGRATED AND NON MODULAR; FOR THE PURPOSE OF CONVENIENT ^{AND EXTREME VERSATILE} PATCHING, THE PATCH BAYS OCCUPY A LOCALIZED PANEL SPACE SO TO AVOID THE PATCHCORD-ACROSS-COMPULPANEL MAZE. THIS METHOD REQUIRES A BIT MORE FAMILIARIZATION WITH THE PANEL LAYOUT ^{AS ~~IT~~ ^{CONTROL} ^{PLUGS} ^{TO} ^{THE} ^{MODULE} ^{STRIPS}} AS COMPOLS AND PATCH JACKS ARE PHYSICALLY SEPERATED.

PATCHES ARE ACCOMPLISHED WITH POINT TO POINT PATCH CORDS, UTILIZING THE 96 JACKS ON EACH BAY OF BOXES 1, 2, & 3. MULTIPLE CONNECTIONS ARE MADE IN ANY OF 3 WAYS: MULTIPLE OUTPUTS FROM MODULES, 4-JACK PANEL MULTIPLES, 3-LEADED PATCHCORDS (IDENTIFIED BY WHITE BAND). PATCHCORDS ARE COLOR CODED ACCORDING TO LENGTH.

ANY COMBINATION OF INPUTS/OUTPUTS MAY BE CONNECTED BY PATCHING WITHOUT POSSIBLE DAMAGE TO THE ELECTRONICS.

Each
5 1/4" x 19"
x 2

SIGNAL STANDARDS

STANDARD AUDIO SIGNAL IS NORMALIZED AT $\pm 5V$ PEAK TO PEAK.

STANDARD CONTROL SIGNAL IS 0 TO $\pm 5V$

GATE AND TRIGGER INPUTS LOOK FOR A THRESHOLD CROSSING
NORMALIZED AT ABOUT $5V$.

TRIGGER INPUTS ONLY CARE ABOUT A TRANSITION, USUALLY LO TO HI.

GATE INPUTS ALSO ACT AS TO AN ^{INPUT} HIGH MAINTAINED SIGNAL.

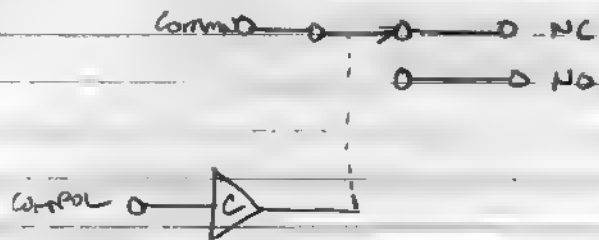
ANY WAVEFORM MAY BE APPLIED TO THESE TWO INPUTS.

PITCH CONTROL IS 1VOLT PER OCTAVE STANDARD.

INPUT IMPEDANCES ARE 100K NOMINAL

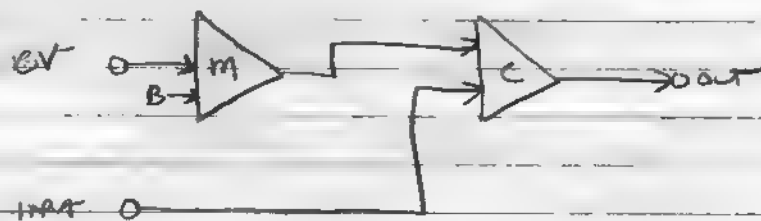
OUTPUT ... ARE 1K NOMINAL

BILATERAL SWITCH



AN ELECTRONIC SWITCH, SPDT. THE SWITCH FLIPS TO THE NORMALLY OPEN TERMINAL WHEN THE CONTROL INPUT GATE CROSSES A THRESHOLD OF $2 + IV$. THERE IS A SMALL SIGNAL LOSS THROUGH THE SWITCH, AS WELL AS AN INCREASE IN OUTPUT Z . THE IMPORTANT LIMITING FACTOR IS THAT THE SWITCH WILL NOT PASS SIGNALS EXCEEDING $\pm 6V$. SIGNALS LARGER THAN THESE LIMITS WILL BE CLIPPED. SIGNALS CAN PASS IN EITHER DIRECTION, WITH THE COMMON TERMINAL BEING USED AS EITHER A SOURCE OR DESTINATION.

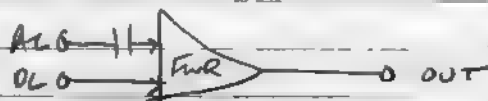
COMPARATOR



INPUT IS COMPARED WITH A BIAS VOLTAGE AND A CV MIX. IF INPUT IS HIGHER, OUTPUT IS $+5V$, OTHERWISE ZERO VOLTS. CV IS INVERTED, AND ACTS COUNTER TO KROB.

FULL WAVE RECTIFIER

ABSOLUTE VALUE CIRCUIT WITH ^{MIXED} AC COUPLED + DC COUPLED PARTS



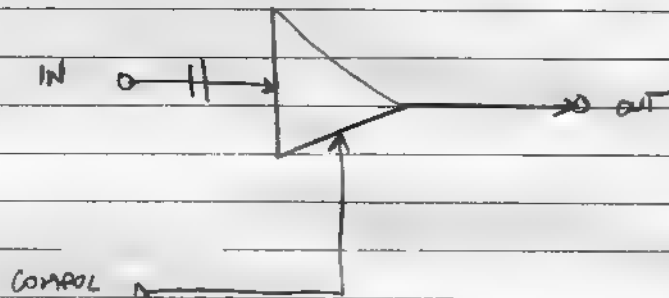
RING MODULATORS



4-QUADRANT VOLTAGE MULTIPLIERS.

$$V_{out} = \frac{V_x \cdot V_y}{5}$$

VCA



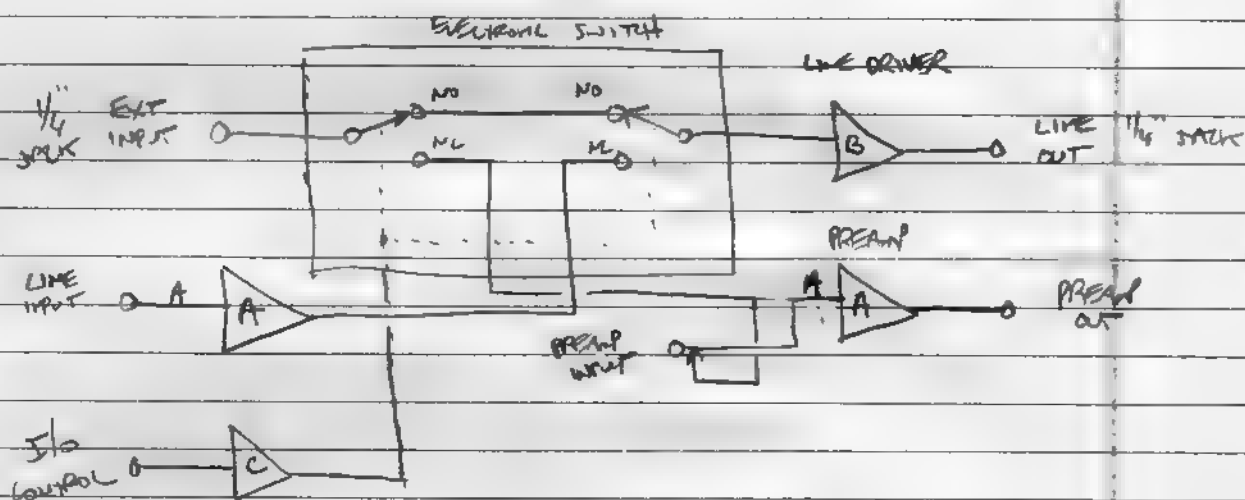
2 QUADRANT MULTIPLIER. THE CONTROL MUST BE POSITIVE. THE INPUT IS AC COUPLED IN THIS VCA; UNITY GAIN IS ACHIEVED WITH THE CV AT +5V. RESPONSE IS LINEARLY PROPORTIONAL TO THE CV.

ENVELOPE GENERATOR



ATTACK AND DECAY TIMES ARE MANUALLY SET AND VARIABLE FROM _____ TO _____. GATE INPUT IS THRESHOLD DETECTED AT $A_{max} + 1V$. MAX ENV IS +5V, MIN IS 0V. ENV SUSTAINS AT +5V WITH CONTINUED HIGH GATE. ACTUAL GATE INPUT LEVEL DOES NOT AFFECT OUTPUT LEVEL.

I/O PROCESSOR



A = ATTENUATED OR VARIABLE GAIN BUFFER

B = FIXED BUFFER

C = COMPARATOR

THIS module PROVIDES interfacing FOR HIGH IMPEDANCE MIKES, GUITARS, ETC., PLUS OUTPUT DRIVE FOR HIGH LEVEL MIKE INPUTS $\approx 2.5V$ PEAK-PEAK. NORMALLY THE EXT IN IS ROUTED TO THE PREAMP FOR BOOSTING TO SYTH LEVELS (10V.P). THE PREAMP HAS A GAIN CONTROL AND A LEVEL LED (GREEN). AT PROPER LEVELS THE LED FLASHES ON INPUT PEAKS. SIMULTANEOUSLY THE LINE DRIVER IS CONNECTED TO A LEVEL MATCHER FOR TO SEND THE BOOSTED SIGNAL OUT TO THE AMP AT PROPER LEVELS.

A GATE SIGNAL TO THE I/O CONTROL INPUT WILL FLIP THE SWITCH TO THE "out" POSITION, ROUTING THE INPUT SIGNAL STRAIGHT THROUGH TO THE AMP VIA A UNITY GAIN BUFFER. A BOUNCESS GATE SHOULD BE USED FOR POPLESS SWITCHING.

THE PREAMP INPUT CAN BE ACCESSED FOR BOOSTING SIGNALS WITHIN THE SYTH. WITH A GAIN OF $\approx 6 \times$ MAX.

EXT INPUT IMP = 110K
 LINE DRIVER OUT $\approx 680\Omega$
 LINE INPUT $\approx 50K$
 PREAMP INPUT $\approx 33K$
 PREAMP OUT $\approx 1K$
 CONTR. INPUT $\approx 100K$

NOT NECESSARY
 - OBTAINABLE FROM
 SCHEMATICS

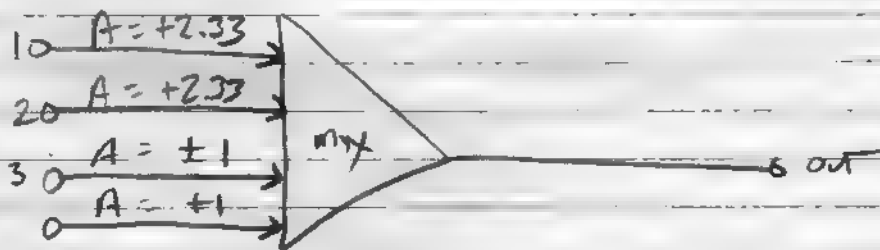
VCO



THIS VCO IS A WIDE RANGE VOLTAGE CONTROLLED TRIANGLE WAVE OSCILLATOR, THE FREQ RANGE BEING FROM .05 KHZ TO 20 KHZ. A I_V/O_V INPUT AND AN ATTENUATED V_I INPUT ARE PROVIDED.

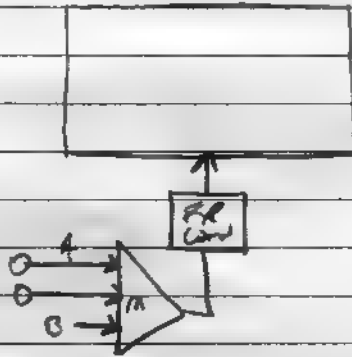
DC MIXER

A 4-IN, 1-OUT DC MIXER. INPUTS 1 + 2 HAVE AUDIO TAPER ATTENUATORS AND CAN PROVIDE A MAXIMUM GAIN OF 2.333. INPUT 3 IS CENTER-OFF, INVERTING TO CC AND NON-INV TO COUNTERCLOCKWISE ROTATIONS, MAXIMUM GAIN = ± 1 . INPUT 4 IS A UNITY GAIN NON INVERTING W/O (FOR ATTENUATED) INPUT.



VCF

THIS VCF IS AN ~~EXPERIMENTAL~~ UNCONVENTIONAL 4TH ORDER STATE VARIABLE



JUST-TUNED SCALE COMPONENT RATIOS

	X Unison	X Octave	Name	Components
1.	1/1	1/2	Unison	U
2.	16/15	8/15	Halftone	HU
3.	10/9	5/9	Minor tone	MU
4.	9/8	9/16	Whole tone	WU
5.	6/5	3/5	Minor third	HWU
6.	5/4	5/8	Major third	MWU
7.	4/3	2/3	Perfect fourth	HMWU
8.	45/32	45/64	Augmented fourth	MW ² U
9.	64/45	32/45	Diminished fifth	H ² MWU
10.	3/2	3/4	Perfect fifth	HMW ² U
11.	8/5	4/5	Minor sixth	H ² MW ² U
12.	5/3	5/6	Major sixth	H ² M ² W ² U
13.	16/9	8/9	Grave min. 7th	H ² M ² W ² U
14.	9/5	9/10	Minor seventh	H ² MW ³ U
15.	15/8	15/16	Major seventh	H ² M ² W ³ U
16.	2/1	1/1	Octave	2U

Compiled by Richard Brewster, August 1980

JUST-TUNED SCALE COMPONENT RATIOS

	X Unison	X Octave	Name	Components
1.	1/1	1/2	Unison	U
2.	16/15	8/15	Halftone	HU
3.	10/9	5/9	Minor tone	MU
4.	9/8	9/16	Whole tone	WU
5.	6/5	3/5	Minor third	HWU
6.	5/4	5/8	Major third	MWU
7.	4/3	2/3	Perfect fourth	HMWU
8.	45/32	45/64	Augmented fourth	MW ² U
9.	64/45	32/45	Diminished fifth	H ² MWU
10.	3/2	3/4	Perfect fifth	HMW ² U
11.	8/5	4/5	Minor sixth	H ² MW ² U
12.	5/3	5/6	Major sixth	HM ² W ² U
13.	16/9	8/9	Grave min. 7th	H ² M ² W ² U
14.	9/5	9/10	Minor seventh	H ² MW ³ U
15.	15/8	15/16	Major seventh	HM ² W ³ U
16.	2/1	1/1	Octave	2U

Compiled by Richard Brewster, August 1980

JUST-TUNED SCALE COMPONENT RATIOS

	X Unison	X Octave	Name	Components
1.	1/1	1/2	Unison	U
2.	16/15	8/15	Halftone	HU
3.	10/9	5/9	Minor tone	MU
4.	9/8	9/16	Whole tone	WU
5.	6/5	3/5	Minor third	HWU
6.	55/4	5/8	Major third	NWU
7.	4/3	2/3	Perfect fourth	HMWU
8.	45/32	45/64	Augmented fourth	NW ² U
9.	64/45	32/45	Diminished fifth	H ² MWU
10.	3/2	3/4	Perfect fifth	HMW ² U
11.	8/5	4/5	Minor sixth	H ² MW ² U
12.	5/3	5/6	Major sixth	HM ² W ² U
13.	16/9	8/9	Grave min. 7th	H ² M ² W ² U
14.	9/5	9/10	Minor seventh	H ² MW ³ U
15.	15/8	15/16	Major seventh	HM ² W ³ U
16.	2/1	1/1	Octave	2U

Compiled by Richard Brewster, August 1980

JUST SCALE COMPONENTS

<u>RATIO</u>	<u>DECIMAL</u>	<u>NAME</u>	<u>COMPONENTS</u>
1/1	1.00000	UNISON	
16/15	1.06667	SEMITONE	S
10/9	1.11111	MINOR TONE	m
9/8	1.12500	WHOLE TONE	W
256/225	1.13777		S ²
32/27	1.18519		Sm
6/5	1.20000	MINOR THIRD	SW
100/81	1.23457		m ²
5/4	1.25000	MAJOR THIRD	MW
81/64	1.26563		W ²
32/25	1.28000		S ² W
4/3	1.33333	PERFECT FOURTH	SWm
27/20	1.35000		SW ²
25/18	1.38888		m ² W
45/32	1.40625	AUGMENTED FOURTH	mW ²
64/45	1.42222	DIMINISHED FIFTH	S ² mW
36/25	1.44000		S ² W ²
46/27	1.48148		Sm ² W
3/2	1.50000	PERFECT FIFTH	SmW ²
192/125	1.53600		S ³ W ²
25/16	1.56250		m ² W ²
128/81	1.58025		S ² m ² W
8/5	1.60000	MINOR SIXTH	S ² mW ²
81/50	1.62000		SW ³
5/3	1.66667	MAJOR SIXTH	Sm ² W ²
27/16	1.68750		SmW ³
128/75	1.70666		S ³ mW ²
125/72	1.73611		Sm ³ W ²
225/128	1.75781	HARMONIC MINOR SEVENTH	m ² W ³
16/9	1.77778	GRAVE MINOR SEVENTH	S ² m ² W ²
9/5	1.80000	MINOR SEVENTH	S ² mW ³
50/27	1.85185	GRAVE MAJOR SEVENTH	Sm ³ W ²
15/8	1.87500	MAJOR SEVENTH	Sm ² W ³
250/128	1.95313		m ³ W ³
2/1	2.00000	OCTAVE	

1/1	1.00000	UNISON
16/15	1.06667	SEMITONE
15/14	1.07143	
14/13	1.07692	
13/12	1.08333	
12/11	1.09091	
11/10	1.10000	
10/9	1.11111	MINOR TONE
9/8	1.12500	MAJOR TONE
8/7	1.14286	
15/13	1.15385	
7/6	1.16667	
13/11	1.18182	
6/5	1.20000	MINOR 3RD
11/9	1.22222	
16/13	1.23077	
5/4	1.25000	MAJOR 3RD
14/11	1.27273	
9/7	1.28571	
13/10	1.30000	
4/3	1.33333	PERFECT 4TH
15/11	1.36364	
11/8	1.37500	
7/5	1.40000	
10/7	1.42857	
13/9	1.44444	
16/11	1.45454	
3/2	1.50000	PERFECT 5TH
14/9	1.55555	
11/7	1.57143	
8/5	1.60000	MINOR 6TH
13/8	1.62500	
5/3	1.66667	MAJOR 6TH
12/7	1.71429	
7/4	1.75000	HARMONIC MINOR 7TH (NOT REALLY) 225/128 REALLY
16/9	1.77778	GRAVE MINOR 7TH
9/5	1.80000	MINOR 7TH
11/6	1.83333	
13/7	1.85714	
15/8	1.87500	MAJOR 7TH

31 TONE SCALE

JUST SCALE TONES

x 1	1.00000	1.00000	UNISON	1/1
2	1.02261			
x 3	1.04573	1.04167		75/72
x 4	1.06938	1.06667	SEMITONE	16/15
5	1.09356			
x 6	1.11829	1.11111	MINOR TONE	10/9
7	1.14357	1.12500	WHOLE TONE	9/8
8	1.16943			
x 9	1.19587	1.20000	MINOR 3RD	6/5
10	1.22291			
x 11	1.25057	1.25000	MAJOR 3RD	5/4
12	1.27894			
13	1.30776			
x 14	1.33733	1.33333	FOURTH	4/3
15	1.36757			
x 16	1.39849	1.40625	AUG. FOURTH	45/32
x 17	1.43011	1.42222	Dim FIFTH	64/45
18	1.46245			
x 19	1.49552	1.50000	FIFTH	3/2
20	1.52933			
x 21	1.56391	1.56250		25/16
x 22	1.59928	1.60000	MINOR 6TH	8/5
23	1.63544			
x 24	1.67242	1.66667	MAJOR 6TH	5/3
25	1.71023			
26	1.74890			
x 27	1.78845	1.77778	GRAVE MINOR 7TH	16/9
28	1.82889			
x 29	1.87024	1.875	MAJOR 7TH	15/8
30	1.91253			
31	1.95578			

JUST GENERATOR

CAPABLE OF MULTIPLICATION BY	11/1	UNISON
9/16	9/8	WHOLE TONE
3/5	6/5	MINOR THIRD
5/8	5/4	MAJOR THIRD
2/3	4/3	PERFECT FOURTH
3/4	3/2	PERFECT FIFTH
4/5	8/5	MINOR SIXTH
5/6	5/3	MAJOR SIXTH
1/10	9/5	MINOR SEVENTH
15/16	15/8	MAJOR SEVENTH
2/1		OCTAVE

DESIGN CIRCUITS

FOR EITHER:

- MULTIPLICATION BY
9/8, 10/9, 16/15
- DIVISION BY SAME
- MULTIPLICATION BY
8/9, 9/10, 15/16
- DIVISION BY SAME

NEED MULT + DIVIDE BY 9

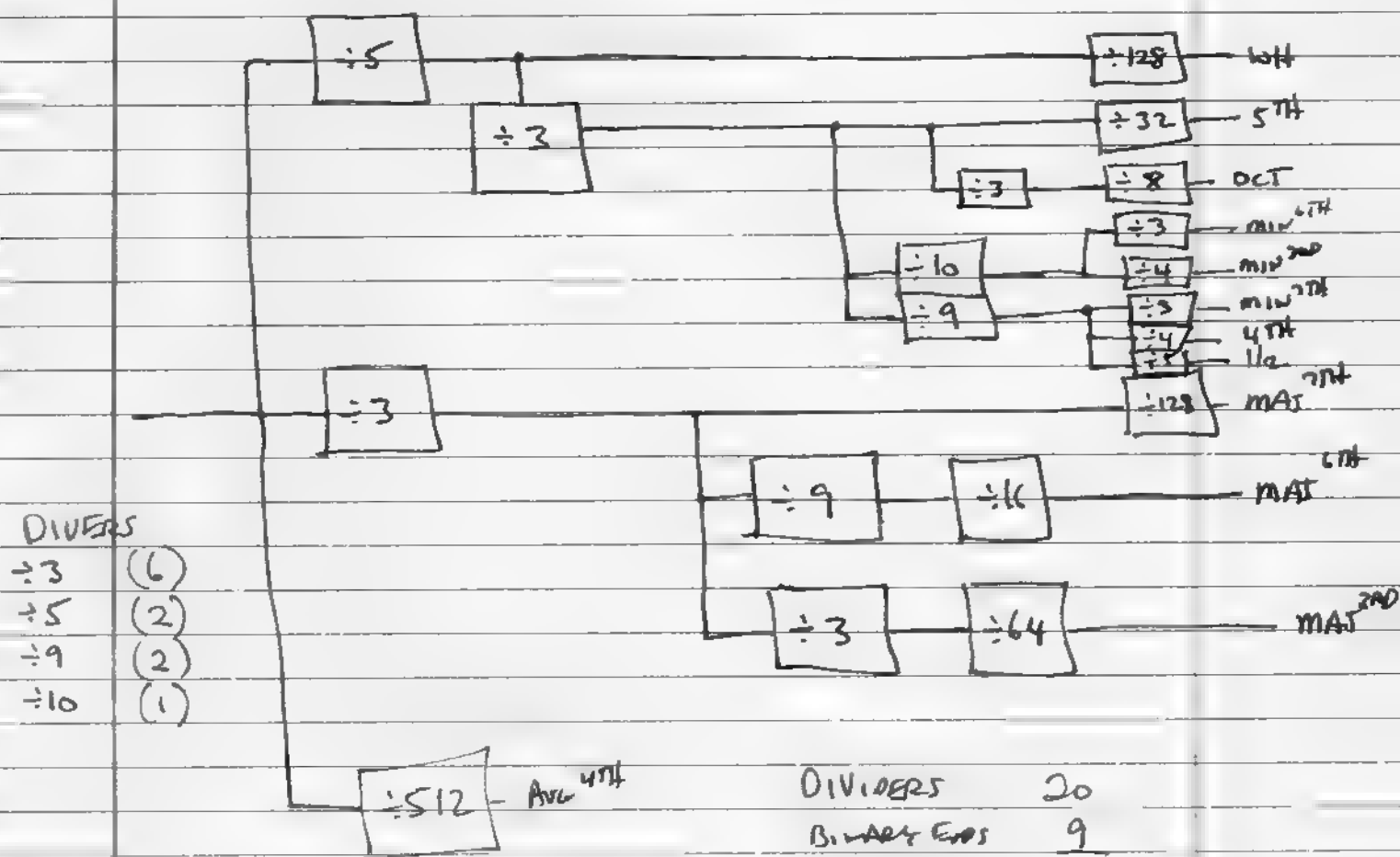
NEED ①	MULT BY 10	OR ②	DIV BY 10
	DIV BY 8		MULT BY 8
	MULT BY 16		DIV BY 16
	DIV BY 15		MULT BY 15

TONES WANTED:

360/720	1/2	1/1	UNISON	C
360/675	8/15	16/15	HALF TONE	
360/640	9/16	9/8	WHOLE TONE	D
360/600	3/5	6/5	MINOR 3RD	
360/576	5/8	5/4	MAJOR 3RD	E
360/540	2/3	4/3	FOURTH	F
360/480	3/4	3/2	FIFTH	G
360/450	4/5	8/5	MINOR SIXTH	
360/432	5/6	5/3	MAJOR SIXTH	A
360/405	8/9	16/9	CRAB MINOR SEVENTH	
360/384	15/16	15/8	MAJOR SEVENTH	B
360/360	1/1	2/1	OCTAVE	C

360/512	45/64	44/45	45/32	diminished 5TH
				Aug 4TH

✓	1/2	15.9.5	15.15.3			
✓	W H O R E	5.128			15.5.9	15.9.5
✓	MIN ^{2ND}	15.10.4	15.5.8	15.10.4	15.5.8	15.9.3
✓	MAT ^{2ND}	9.64		15.10.3	15.5.6	15.9.4
✓	4TH	15.9.4			15.9.3	
✓	AVE 4TH	512			15.9.4	
✓	5TH	15.32			15.6.4	15.3.8
✓	MIN 6TH	15.6.5	15.15.2		15.12.8	
✓	MAT 6TH	9.6.8	3.9.16			
✓	MIN 7TH	15.9.3				
✓	MAT 7TH	3.128				
✓	OCT	15.3.8	15.6.4			

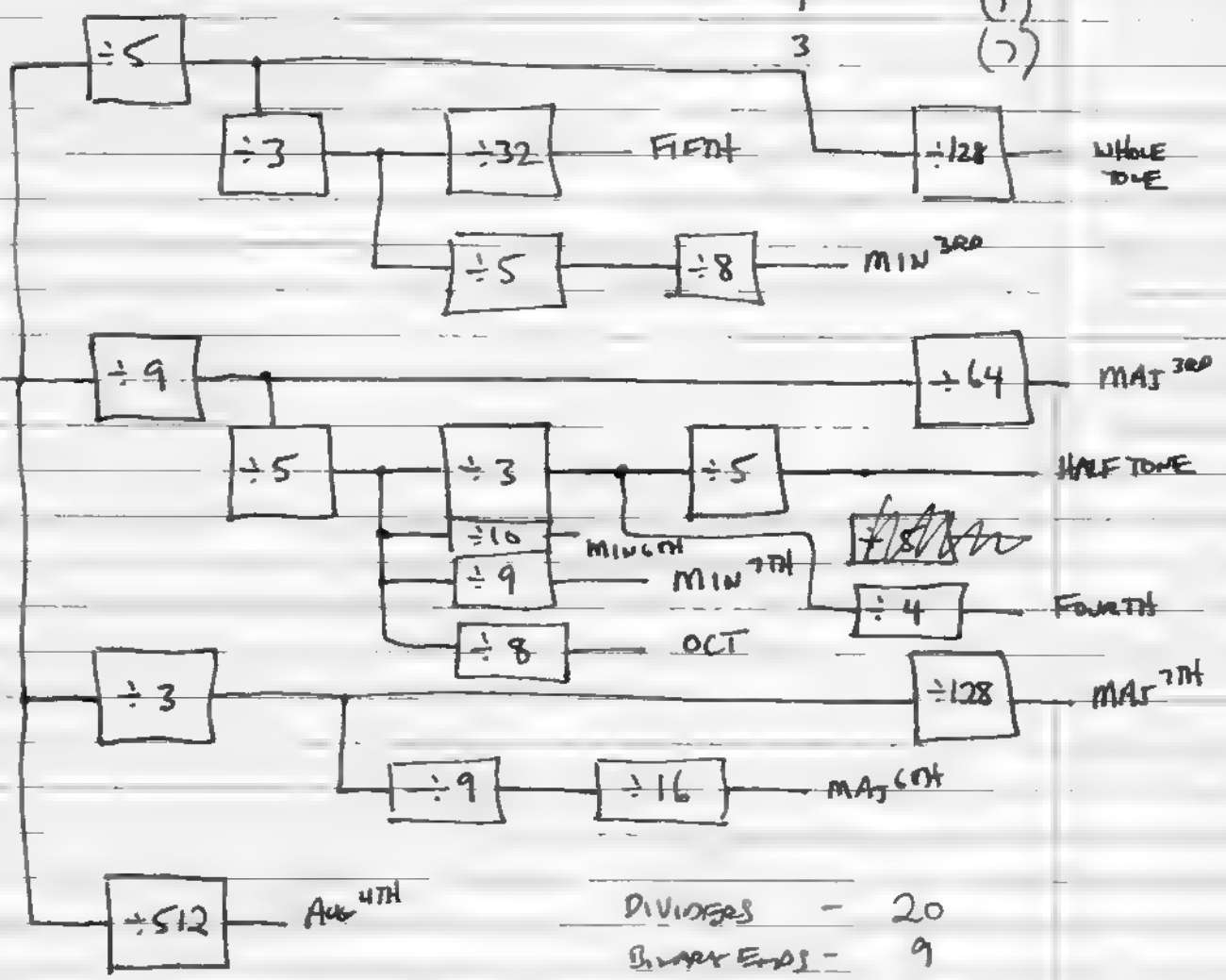


DIVISORS	
$\div 3$	(6)
$\div 5$	(2)
$\div 9$	(2)
$\div 10$	(1)

DIVISORS	20
BINARY ENDS	9
HB ENDS	3

	DIVISORS	
HALF	3 . 9 . 5 . 5	
WHOLE	10 . 64 5 . 128	
MIN ^{3RD}	3 . 5 . 2 . 5 . 4	3 . 5 . 5 . 8
MAY ^{3RD}	9 . 64	
FOURTH	9 . 5 . 2 . 6	9 . 5 . 3 . 4
AUG ^{4TH}	5 . 128	
FIFTH	5 . 6 . 16	5 . 3 . 32
MIN ^{6TH}	9 . 5 . 5 . 2	
MAY ^{6TH}	9 . 3 . 16	
MIN ^{7TH}	9 . 5 . 3 . 3 . 9	
MAY ^{7TH}	3 . 128	
OCT	9 . 5 . 8	

5 . 3	(5)
9 . 5	(5)
9 . 3	(4)
9 . 5 . 3	(3)
5	(8)
9	(3)
3	(7)



Divisors

÷3	(3)
÷5	(4)
÷9	(3)
÷10	(1)

DIVISORS	-	20
INTERVALS	-	9
NB - ENDS	-	3

JUST SCALE INTERVALS

1	UNISON	1.00000	>	1.06667	1	
2	SEMITONE	1.06667	>	1.04167	2	
3	MINORTONE	1.11111	>	1.01250	3	
4	WHOLETONE	1.12500	>	1.06667	1	
5	MINOR 3RD	1.20000	>	1.04167	2	
6	MAJOR 3RD	1.25000	>	1.06667	1	
7	FOURTH	1.33333	>	1.12500	4	
8	FIFTH	1.50000	>	1.06667	1	
9	MINOR 6TH	1.60000	>	1.04167	2	
10	MAJOR 6TH	1.66667	>	1.06667	1	
11	CRANE MINOR 7TH	1.77777	>	1.04167	2	
12	CRANE MAJOR 7TH	1.87500	>	1.04167	2	1.8000

INTERVAL #00258.1 NTC SCALE

1	SEMITONE	1.06667	
2	?	1.04167	
3	?	1.01250	
4	WHOLE TONE	1.12500	

$$\#2 = 10/9 \cdot 15/16 = \frac{150}{144} = 75/72$$

$$\#3 = 11/8 \cdot 9/8 = \frac{99}{64} = 1.546875$$

RATIO OF INTERVALS

1.01250	>	1.02881	
1.04167	>	1.02400	
1.06667	>	1.05469	
1.12500	>		

$$1.05469 > 1.02516 > 1.02036$$

$$1.02881 > 1.00470$$

$$1.02400$$

NOTE

1	UNISON	1	> 1.06667	
2	SEMITONE	1.06667	> 1.05469	
3	WHOLETONE	1.12500	> 1.06667	
4	MINOR 2ND	1.20000	> 1.04167	
5	MAJOR 2ND	1.25000	> 1.06667	
6	FOURTH	1.33333	> 1.05469	OR 1.06667
7	or Aug 4TH Dim 5TH		> 1.06667	OR 1.05469
8	FIFTH	1.50000	> 1.06667	
9	MINOR 6TH	1.60000	> 1.04167	
10	MAJOR 6TH	1.66667	> 1.05469	OR 1.06666
11	Harmon or CRANE minor 7TH		> 1.06666	OR 1.05469
12	MAJOR 7TH	1.87500		

Fourth to Fifth

~~1.33333 > 1.04167~~
~~1.38988 > 1.08000~~
~~1.50000~~

1.33333 > 1.05469
 1.40625 > 1.06666
 1.50000

Aug 4TH

1.33333 > 1.06666
 1.42222 > 1.05469
 1.50000
 Dim 5TH

MAJOR 6TH TO MINOR 7TH

1.66667 > 1.04167
 1.73611

1.66667 > 1.05469
 1.75781 > 1.06666
 Harmon minor
 major 7TH
 1.875

1.66667 > 1.06666
 1.77777 > 1.05469
 1.875

NOTE	NAME	COMPUTATION	RATIO
1	UNISON	1×1	$1:1$
2	SEMITONE	$1 \times \frac{16}{15}$	$16:15$
3	MINOR TONE	$\frac{16}{15} \times \frac{15}{16} \times \frac{10}{9}$	$10:9$
4	WHOLE TONE	$\frac{10}{9} \times \frac{9}{10} \times \frac{9}{8}$	$9:8$
5	MINOR 3RD	$\frac{9}{8} \times \frac{16}{15}$	$6:5$
6	MAJOR 3RD	$\frac{6}{5} \times \frac{15}{16} \times \frac{10}{9}$	$5:4$
7	FOURTH	$\frac{5}{4} \times \frac{16}{15}$	$4:3$
8	FIFTH	$\frac{4}{3} \times \frac{9}{8}$	$3:2$
9	MINOR 6TH	$\frac{3}{2} \times \frac{16}{15}$	$8:5$
10	MAJOR 6TH	$\frac{8}{5} \times \frac{10}{9} \times \frac{15}{16}$	$5:3$
11	GRAVE MINOR 7TH	$\frac{5}{3} \times \frac{16}{15}$	$16:9$
12	GRAVE MAJOR 7TH	$\frac{16}{9} \times \frac{10}{9} \times \frac{15}{16}$	$50:27$

THIS 12 TONE SCALE IS BASED ON THE RATIOS:

$$16:15$$

$$10:9$$

$$9:8$$

12 NOTE JUST SCALE

		INTERVAL	
1	1/1	1/1	UNISON
2	(1/1) (16/15)	16/15	SEMITONE
3	(1/1) (9/8)	9/8	MAJOR TONE
4	(9/8) (16/15) (16/15) (9/8)	6/5	MINOR 3RD
5	(9/8) (10/9)	5/4	MAJOR 3RD
6	(5/4) (16/15)	4/3	FOURTH
7	(5/4) (9/8) (4/3) (16/15)	45/32 64/45	AUGMENTED FOURTH DIMINISHED FIFTH
8	(4/3) (9/8)	3/2	FIFTH
9	(3/2) (16/15)	8/5	MINOR 6TH
10	(3/2) (10/9)	5/3	SIXTH
11	(5/3) (16/15)	16/9	GRAVE MINOR SEVENTH
12	(5/3) (9/8)	15/8	MAJOR 7TH

JUST TUNING COMPONENTS

1	1/1	1/2	UNISON	1	>
2	16/15	8/15	HALF TONE	H	>
3	10/9	5/9	MINOR TONE	M	>
4	9/8	9/16	WHOLE TONE	W	>
5	6/5	3/5	MIN 3RD	HW	>
6	5/4	5/8	MAJ 3RD	MW	>
7	4/3	2/3	4TH	HMW	>
8	45/32	45/64	AUG 4TH	MWW	>
9	64/45	32/45	DIM 5TH	HHMW	>
10	3/2	3/4	FIFTH	HmWN	>
11	8/5	4/5	MIN 6TH	HHmWN	>
12	16/9	5/6	MAJ 6TH	HmmWN	>
13	16/9 5/3	8/9	GRAVE MIN 7TH	HHmmWN	>
14	15/8 9/5	9/10	MINOR 7TH	HHmWWW	>
15	15/8 15/8	15/16	MAJ 7TH	HmmWWW	>
16	2/1	1/1	OCTAVE	2	

SCALE GENERATION FOR

$S = \frac{16}{15}$ HALFTONE
 $m = \frac{10}{9}$ MINOR TONE
 $W = \frac{9}{8}$ WHOLE TONE

COMBINATIONS TO 3RD POWER

~~TERMS~~

	1	2	3	4	5	6
S	S	Sm	SmW	S ² mW	S ² m ² W	S ² m ² W ²
m	m	SW	S ² m	Sm ² W	S ² mW ²	Sm ³ W ²
W	W	mW	S ² W	SmW ²	Sm ² W ²	Sm ² W ³
Sm		S ²	Sm ²	S ² m ²	S ³ mW	S ² mW ³
SW		m ²	SW ²	S ² W ²	Sm ³ W	S ³ mW ²
mW		W ²	mW ²	m ² W ²	SmW ³	S ² m ³ W
SmW			m ² W	S ³ m	S ³ m ²	S ³ m ² W
S ²			S ³	S ³ W	S ³ W ²	S ³ m ³
S ² m			m ³	m ³ W	m ³ W ²	S ³ W ³
S ² W			W ³	Sm ³	S ² m ³	m ³ W ³
m ²				mW ³	m ² W ³	
Sm ²				SW ³	S ² W ³	
m ² W						
W ²						
SW ²						
mW ²						
S ² mW						
Sm ² W						
SmW ²						
S ² m ² W						
S ² mW ²						
Sm ² W ²						
S ² m ² W ²						
S ³						
m ³						
W ³						

$$\frac{1024}{729}$$

$$243$$

$$\frac{25}{16}$$

$$\frac{10}{4} \cdot \frac{8}{4}$$

$$\frac{16}{25}$$

$$\frac{320}{243}$$

$$\frac{A=4}{B=5}$$

$$\frac{512}{405}$$

$$400$$

$$(AB)^2$$

$$1.21363$$

$$1.37174$$

$$1.42383$$

$$1/1 \quad 1.00000$$

$$\frac{2}{5} \cdot \frac{10}{4} = \frac{4}{3}$$

LET $\frac{1}{15} = S$ SEMI TONE
 LET $\frac{1}{9} = M$ MINOR TONE
 LET $\frac{1}{8} = W$ WHOLE TONE

$$1 \quad 1 \cdot S = S$$

$$2 \quad 1 \cdot M = M$$

$$3 \quad 1 \cdot W = W$$

$$4 \quad SW = \text{MINOR 7TH} \quad \frac{6}{5}$$

$$5 \quad MW = \text{MAJOR 7TH} \quad \frac{5}{4}$$

$$SM = ? \quad \frac{16}{15} = \frac{32}{27} = 1.18519$$

$$S^2W \quad \frac{1}{5} \cdot \frac{1}{15} = \frac{1}{75} = \frac{52}{25} = 1.28000$$

$$SWM \quad \frac{1}{5} \cdot \frac{1}{9} = \frac{1}{45} = \text{FOURTH} \quad 1.33333$$

$$SW^2 \quad \frac{1}{5} \cdot \frac{1}{8} = \frac{1}{40} = 1.35000$$

$$SMW \quad \frac{1}{4} \cdot \frac{1}{15} = \frac{1}{60} = \text{FOURTH}$$

$$M^2W \quad \text{MINOR 5TH} \quad \frac{1}{4} \cdot \frac{1}{9} = \frac{1}{36} = \frac{25}{18} = 1.38888$$

$$W^2M \quad \text{MAJOR 4TH} \quad \frac{1}{4} \cdot \frac{1}{8} = \frac{1}{32} = 1.40625$$

$$S^2WM \quad \text{MIN 5TH} \quad \frac{4}{3} \cdot \frac{1}{15} = \frac{4}{45} = 1.42222$$

$$M^2WS \quad \text{MIN 4TH} \quad \frac{4}{3} \cdot \frac{1}{9} = \frac{4}{27} = 1.48148$$

$$W^2MS \quad \text{MIN 3RD} \quad \frac{4}{3} \cdot \frac{1}{8} = \frac{1}{6} = 1.50000$$

$$S^2W^2M \quad \frac{3}{2} \cdot \frac{1}{15} = \frac{1}{10} = \frac{8}{5} = \text{MIN 6TH} = 1.60000$$

$$SW^2M^2 \quad \frac{3}{2} \cdot \frac{1}{9} = \frac{1}{6} = \frac{5}{3} = \text{MAJ 6TH} = 1.66667$$

$$S^2W^2M^2 \quad \frac{5}{3} \cdot \frac{1}{15} = \frac{1}{9} = \text{MAJ 7TH} = 1.77778$$

$$SW^3M^2 = \frac{5}{3} \cdot \frac{1}{8} = \frac{5}{24} = \text{MAJ 7TH} = 1.875$$

$$\frac{4}{3} \cdot \frac{6}{5} = \frac{8}{5}$$

$$S^2 = \frac{256}{225}$$

$$M^2 = \frac{100}{81}$$

$$W^2 = \frac{81}{64}$$

1 { $S = \times \frac{16}{15} \checkmark$ Semi
 $M = \times \frac{10}{9} \checkmark$ MINOR TONE
 $W = \times \frac{9}{8} \checkmark$ MAJOR TONE

2 { $SM = \frac{32}{27} \checkmark +.18519$
 $SW = \times \frac{6}{5} \checkmark +.20000$
 $MW = \times \frac{5}{4} \checkmark +.25000$
 $S^2 = \frac{256}{225} \checkmark +.137777$ SHARP MAJOR TONE
 $M^2 = \frac{100}{81} \checkmark +.23457$ FLAT MAJOR 3RD
 $W^2 = \frac{81}{64} \checkmark +.26563$ SHARP MAJOR 3RD
 $S^3 = \frac{4096}{3375}$
 $M^3 = \frac{1000}{729}$
 $W^3 = \frac{729}{512}$
 $SMW = \times \frac{4}{3} \checkmark +.33333$

3 { $S^2M = \frac{256}{2025} = \frac{512}{405}$
 $S^2W = \frac{32}{25} \checkmark +.28000$
 $SM^2 = \frac{320}{243}$
 $SW^2 = \frac{27}{20} \checkmark +.35000$
 $MW^2 = \frac{45}{32} \checkmark +.40625$
 $M^2W = \frac{25}{18} \checkmark +.38888$
 $SMW(W) = \times \frac{3}{2} \checkmark +.50000$
 $SMW(M) = \frac{40}{27} \checkmark +.48148$
 $SMW(S) = \frac{64}{45} \checkmark +.42222$
 $(SM)^2 = \frac{1024}{729}$ #
 $(SW)^2 = \frac{36}{25} \checkmark +.44000$
 $(MW)^2 = \frac{25}{16} \checkmark +.56250$

4 { $SM \cdot S^2 = \frac{32}{27} \cdot \frac{256}{225} = \frac{8192}{6075}$
 $SW \cdot S^2 = \frac{6}{5} \cdot \frac{256}{225} = \frac{1536}{1125}$
 $MW \cdot M^2 = \frac{5}{4} \cdot \frac{100}{81} = \frac{500}{324} = \frac{250}{162}$
 $SM \cdot M^2 = \frac{32}{27} \cdot \frac{100}{81} = \frac{3200}{2187}$
 $MW \cdot W^2 = \frac{5}{4} \cdot \frac{729}{512} = \frac{3645}{4096}$
 $SW \cdot W^2 = \frac{6}{5} \cdot \frac{81}{64} = \frac{486}{320} = \frac{243}{160}$

(S ₀ W)(Sm)	$4/3 \cdot \frac{32}{27} = \frac{128}{81}$	1.58025
(SmW)(SW)	$4/3 \cdot \frac{6}{5} = \frac{8}{5}$	1.60000
(SmW)(mW)	$4/3 \cdot \frac{5}{4} = \frac{5}{3}$	1.66667
(SmW) S ²	$4/3 \cdot \frac{25}{27} = \frac{100}{27}$	
(SmW) m ²	$4/3 \cdot \frac{100}{81} = \frac{400}{243}$	
(SmW) W ²	$4/3 \cdot \frac{81}{64} = \frac{324}{192} = \frac{62}{46} = \frac{31}{23}$	1.68750
(Sm) ² · S	$\frac{1024}{729} \cdot \frac{16}{15} = \frac{16384}{10935}$	
(SW) ² · S	$\frac{12}{25} \cdot \frac{4}{5} = \frac{48}{125}$	1.53600
(mW) ² · m	$\frac{25}{144} \cdot \frac{10}{9} = \frac{125}{72}$	1.73611
(Sm) ² · m	$\frac{1024}{729} \cdot \frac{10}{9} = \frac{10240}{6561}$	
(mW) ² · W	$\frac{25}{16} \cdot \frac{9}{8} = \frac{225}{128}$	1.75781
(SW) ² · W	$\frac{36}{25} \cdot \frac{9}{8} = \frac{81}{50}$	1.62000
(Sm) ² · W ²	$\frac{1024}{729} \cdot \frac{81}{64} = \frac{128}{9}$	1.77778
SmW · m ² W	$4/3 \cdot \frac{25}{18} = \frac{100}{54} = \frac{50}{27}$	1.85185
SmW · mW ²	$4/3 \cdot \frac{125}{32} = \frac{125}{24}$	1.87500
SmW · SW ²	$4/3 \cdot \frac{27}{20} = \frac{36}{20} = \frac{9}{5}$	1.80000
SmW · S ² W	$4/3 \cdot \frac{32}{25} = \frac{128}{75}$	1.70666
SmW · Sm ²	$4/3 \cdot \frac{320}{243} = \frac{1280}{729}$	
SmW · S ² m	$4/3 \cdot \frac{512}{405} = \frac{2048}{1215}$	
S ³ m ³	$\frac{4096}{2727} \cdot \frac{1000}{729}$	
S ² W ³	$\frac{4096}{2727} \cdot \frac{729}{512}$	
m ³ W ³	$\frac{1000}{729} \cdot \frac{729}{512} = \frac{250}{128}$	1.95313

MAJOR JUST SCALE

UNISON	1/1	> 9/8
WHOLE TONE	9/8	> 10/9
MAJOR 3RD	5/4	> 16/15
FOURTH	4/3	> 9/8
FIFTH	3/2	> 10/9
MAJOR 6TH	5/3	> 9/8
MAJOR 7TH	15/8	> 16/15
OCTAVE	2/1	

MINOR JUST SCALE

UNISON	1/1	> 9/8
WHOLE TONE	9/8	> 16/15
MINOR 3RD	6/5	> 10/9
FOURTH	4/3	> 9/8
FIFTH	3/2	> 16/15
MINOR 6TH	8/5	> 9/8
MINOR 7TH	9/5	> 10/9
OCTAVE	2/1	

$$\frac{5}{4} \cdot \frac{8}{9} = \frac{10}{9}$$

$$\frac{4}{3} \cdot \frac{4}{5} = \frac{16}{15}$$

$$\frac{3}{2} \cdot \frac{3}{4} = \frac{9}{8}$$

$$\frac{5}{3} \cdot \frac{2}{3} = \frac{10}{9}$$

$$\frac{15}{8} \cdot \frac{2}{3} = \frac{5}{4}$$

$$\frac{2}{1} \cdot \frac{8}{15} = \frac{16}{15}$$

$$2 \times = \frac{15}{8} \cdot \frac{15}{16}$$

$$\frac{2}{1} \cdot \frac{5}{9} = \frac{10}{9}$$

$$2 \cdot \frac{15}{16} = \frac{30}{16} = \frac{15}{8}$$

$$\frac{2}{1} \cdot \frac{9}{16} = \frac{18}{16} = \frac{9}{8}$$

$$\frac{10}{9} \times = \frac{3}{5} \cdot \frac{9}{10} = \frac{27}{50}$$

$$\frac{9}{8} \cdot \frac{16}{9} = \frac{16}{8} = 2$$

$$3 \cdot \frac{6}{5} \cdot \frac{9}{10} = \frac{27}{25}$$

$$15/8 \cdot \frac{8}{9} = \frac{5}{3}$$

$$\frac{16}{9} \cdot \frac{3}{5} = \frac{16}{15}$$

$$\frac{5}{4} \cdot \frac{9}{10} = \frac{9}{8}$$

$$3 \cdot \frac{27}{25} \cdot \frac{10}{9} = \frac{108}{25}$$

$$2 \cdot \frac{9}{16} = \frac{18}{16} = \frac{9}{8}$$

$$\frac{6}{5} \cdot \frac{8}{9} = \frac{48}{45} = \frac{16}{15}$$

$$\frac{2}{4/3} \cdot \frac{5}{1} = \frac{10}{9}$$

$$\frac{3}{2} \cdot \frac{3}{4} = \frac{9}{8}$$

$$\frac{8}{5} \cdot \frac{2}{3} = \frac{16}{15}$$

$$\frac{8}{5} \cdot \frac{16}{15} = \frac{128}{75}$$

$$\frac{8}{5} \cdot \frac{10}{9} = \frac{16}{9} \text{ GRAVE MINOR 7TH}$$

$$\frac{8}{5} \cdot \frac{9}{8} = \frac{9}{5} \text{ MINOR 7TH}$$